

A Multimodal Framework for Computer Mediated Learning: The Reshaping of Curriculum Knowledge and Learning

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Abstract

In this thesis I turn the lens of multimodality on technology-mediated learning in classrooms. I analyse the representational and communicative modes that a range of computer applications make available to students including still image, movement, speech, sound-effect, and writing.

Two central aims inform the thesis. The first aim is to provide a better theoretical understanding of the relationship between the multimodal meaning making resources made available by new technologies, school knowledge and practices. The second aim is to contribute to the development of multimodal theory through its application to technology-mediated learning. In the process I comment on the questions that this raises for conceptions of literacy.

In the thesis I develop a multimodal analytical framework for the examination of the characteristics of technology-mediated learning by presenting a detailed analysis of three examples of technology-mediated learning. The first concerns the use of a CD-ROM version of the Steinbeck novel *Of Mice and Men* in the English classroom. The focus is on the transformation of the entity 'character' on the one hand, and the practices of reading on the other, in the move from page to screen. The second example explores students' use of a computer programming application *Toontalk* and the production of the mathematical concepts of 'rule' and 'bounce' through game building. The multimodal construction of the entity 'states of matter', in a CD-ROM *Multimedia Science School* is explored in the third example. Drawing on these instances of representation in English, Mathematics, and Science I investigate how the multimodal representations afforded by new technologies reshape school knowledge, and, in doing so, influence (possibilities for) learning, subjectivity and traditional concepts of literacy. The thesis demonstrates that traditional conceptions of literacy are reshaped through technology-mediated learning and can be thought of as a process of multimodal design.

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The Organisation of the Thesis

The thesis is organised in three parts. Part I consists of chapters One through to Three and in these chapters I provide an introduction and overview to the thesis, its aims, the questions and themes that inform it, and outline the theoretical concepts and methodological approach that informs it. In Part II, consisting of Chapters Four, Five and Chapter Six, I explore the semiotic potentials of new technologies for learning. I do so through the analysis of three examples of technology-mediated learning each of which explores an instance of teaching and learning with a specific computer application set in the English, Mathematics, and Science classroom respectively. In each chapter I show how the resources of screen re-shaped curriculum knowledge and classroom practice. Part III consists of Chapters Seven and Eight, in each of these chapters I return to the two aims of the thesis. In Chapter Seven I draw on the findings of the analysis to discuss literacy, knowledge practices and the implications for technology-mediated learning more broadly. In my concluding chapter, Chapter Eight I discuss the contribution of the thesis to the development of multimodal theory.

Part I: A Multimodal Framework for Technology-Mediated Learning

1. Multimodality and the Screen

In Chapter One I describe the focus of the thesis, its aims, and the research questions that it sets out to address. I review the literature on technology-mediated learning in relation to the central themes and concerns of the thesis. The six themes are the multimodal character of technology-mediated learning, the role of speech and writing, the interaction of modes on screen, multimodal learning, multimodal literacy, and the multimodal engagement of students with the resources of screen.

2. Turning a Multimodal Lens on Technology-Mediated Learning

In Chapter Two I describe the theoretical perspective of the thesis. I bring together a social semiotic theory of representation and communication (Halliday, 1978, 1985; Hodge and Kress, 1988; Kress, et. al, 2001; Kress and van Leeuwen, 2001), and a social-cultural theory of learning (Engestrom, 1999; Daniels, 2001; Russell, 2002). I introduce and discuss the concepts that inform the theoretical framework of the thesis including semiotic mediation, activity system, sign, mode, materiality, modal affordance, and site of display and design. I conclude the chapter by exploring the implications of these concepts for learning.

3. Towards a Multimodal Analysis

The ways in which these theoretical concepts are applied to the context of technology-mediated learning in the thesis are outlined in Chapter Three. More specifically I describe the dimensions for the analysis of visual communication, colour, animated movement, sound, and gaze in some detail. I briefly describe the data analysed in the thesis, and discuss the issues data collection, the use of video as a method of collecting data, sampling, and transcription.

Part II: Multimodality and Technology-Mediated Learning

This part of the thesis provides the empirical data in the form of the multimodal analysis of three illustrative examples of technology-mediated teaching and learning in the classroom. This includes analysis of the use of two CD-ROMs (*Of Mice and Men* (1996) and *Multimedia School Science* (2001)), and Toontalk, a computer programming application. In each chapter I deal with a specific school subject (English, Mathematics and Science) and focus in on an entity that is significant to that curriculum. The multimodal analysis that I present in each chapter asks how curriculum entities are realised through the range of modes that the computer application makes available. Having described the resources made available in the

classroom via the computer applications in each chapter I go on to analyse student interaction with these resources. I examine the ways in which these multimodal resources reshape knowledge, their impact on the practices of students and more broadly what this might mean for technology-mediated learning. I develop the themes outlined in Chapter One throughout this analysis.

4. The Multimodal Reshaping of Curriculum Entities in School English in the Move from Page to Screen

In Chapter Four I focus on the use of the CD-ROM *Of Mice and Men* (1996) of the Steinbeck novel *Of Mice and Men* (Steinbeck, 1937) in a secondary school English classroom. I explore how, in the move from page to screen, a range of representational modes (including image, movement, gesture, and voice) are available as meaning-making resources. The concept of ‘character’ is one of the central concepts in the National Curriculum for English (DFEE, 1999) and working with this concept I show how the shift from the written page to the multimodal screen entails a shift in the construction of ‘character’. Through detailed multimodal analysis of several students’ engagement with the CD-ROM I argue that student interaction with the resources of the CD-ROM as a visual multimodal text demand that ‘reading’ and the process of learning within school English be thought of as more or other than a linguistic accomplishment.

5. Mathematics and the Multimodal Construction of ‘Rule’ and ‘Bounce’ on Screen

In Chapter Five I focus on a computer programming application ‘Toontalk’ and its use in a Primary school computer club. Toontalk aims to give children access to a conceptual understanding of maths through the process of building computer games. In the first part of the chapter I analyse the modal resources that the application makes available to the user. In order to demonstrate that these are the result of a designer’s choice from a range of available potentials, not an automatic consequence

of the choice of medium in and of itself, I compare the application with two others, Logo Imagine, and Pathways. Logo Imagine can be crudely characterised as a writing system, and Pathways as a visual object orientated system. While in the first part of the chapter I focus on the potentials of the medium and modal resources of the programmes, in the second part of the chapter I focus on how two students engaged with the modal potentials of Toontalk in building a game. Through a detailed multimodal analysis of the students making their game I look at two students' construction of the entity 'bounce'. The analysis centres on the impact of modes (including still image, gesture, posture, speech, animated movement and writing) on the emergence of the mathematical concept of 'bounce'. I show that the modal resources that the application makes available to the user enables them to realise the entity 'bounce' in quite different ways. The chapter concludes that the choice of representational modes in the design of a program is central to the engagement of the user with it.

6. The Multimodal Construction of the School Science Entities 'states of matter' and 'particles' on Screen

In chapter six I explore how the multimodal resources of the computer screen reshape the science curriculum entity 'states of matter'. Throughout the chapter I draw on an illustrative example of a science lesson with a year seven class in which the CD-ROM *Multimedia Science School* (2001) is used to investigate the topic 'states of matter'. In particular, I focus on how these resources result in a shift from the traditional focus on distinct 'states of matter' to a new representation of the process of the transformation from one state of matter to another. Alongside this I examine how these resources re-mediate the practices of students in the science classroom and their agency in the production and construction of knowledge. I conclude that the resources of the screen both reshape the curriculum entities in significant ways and the role of the students in relation to the learning of science.

Part III: New Technology, Multimodal Learning, Literacy and Design across the Curriculum

7. New Technology and Learning

The final part of the thesis consists of Chapter Seven, in which I draw on the theoretical discussion in Part I and the analysis and findings presented in Part II in order to discuss student learning, literacy and new technologies in education more generally. I present a discussion of themes generated by the analysis. I address the ways in which modes are used in different curricular subjects, in particular the question of the specialised use of modes to shape knowledge. The arrangement of modes on the computer screen, the configuration of modes to mean and the interaction of modes on screen are also discussed. I explore the need to re-think the concept of literacy in the multimodal context of technology-mediated learning, in particular the implications for what it means to be literate, and for the assessment of literacy within the school. Further, I discuss the practices involved when learning is mediated by new technology and the potential for modes other than language to contribute to learning as ‘multimodal design’.

8. The Development of Multimodal Theory

In this concluding chapter I address the second aim of the thesis, the question of how the thesis contributes to the development of multimodal theory through its application in the domain of the screen and technology-mediated learning.

Part I:

A Multimodal Framework for Technology-Mediated Learning

1. Multimodality and the Screen

In this chapter I set out the aims of the thesis, the research questions that it addresses and the themes that it develops. These themes are discussed in relation to the literature on technology-mediated learning in order to place the arguments developed in the thesis in context.

The Purpose of the Thesis

In this thesis I turn a multimodal lens on technology-mediated learning in the school classroom. In other words I analyse the representational and communicative modes that technology-mediated learning makes available to students in the school classroom including still image, movement, speech, sound-effect, and writing. In order to do this I focus on three specific computer applications - two CD-ROMs, and a computer programming application. Two aims inform the thesis. The first and central aim of the thesis is to provide a better theoretical understanding of the relationship on the one hand between the multimodal meaning making resources made available by technology, and school knowledge, learning and notions of literacy on the other. The second aim of the thesis is to contribute to the development of multimodal theory through its application to technology-mediated learning. It attempts to achieve this by providing a better understanding of the multimodal resources offered by computer applications. This, I argue, is central to realising the potential of new technology for learning. I examine the multimodal character of technology-mediated learning through the detailed analysis of three examples. Drawing on video and observational data of instances of technology-mediated learning in school English, Mathematics, and Science I examine how such multimodal representations reshape school knowledge.

Multimodality is an emergent theory, and while there is a small (but significant) body of work on multimodal theory that sets out to address the theoretical questions that it raises many of the theoretical concepts and tools remain unsettled (e.g. Kress and van Leeuwen, 1996; Kress and van Leeuwen, 2001; Finnegan, 2002). Despite this, educational researchers have actively taken up multimodal theory across a wide range of learning contexts. This includes, among others, pre-school learning (Lancaster, 2001; Pahl, 1999), bilingual language learners (Kenner, 2000), literacy (Moss 2001; Street, 1998), English education (SEP, 2002), and science education (Kress et al. 2001; O'Halloran, 1998). Multimodality has generated much interest among designers, academics and educational practitioners working in the area of new technologies and technology-mediated learning. However, with a few notable exceptions (e.g. Burn and Parker, 2001; Lemke, 2002; van Leeuwen, 1998) there has been little multimodal research in the field of technology-mediated learning.

Background

The ideas and questions that inform this thesis emerged from watching the children of friends and my own daughter, 'play' and 'work' on computers. I watched them 'read' books, 'play' music, write, draw, build and destroy cities, and kill armies. I listened to the sound-effects of the software, watched the visual display of animated (revolving) icons and characters, the use of colour on screen, the spatial construction of the screen environment, and all the time I wondered what was going on. The children sat at the computer, they looked intently at the screen, moved the mouse, clicked on icons, pressed keys, and pointed at things on the screen. In these moments I wondered whether the multimodal theory of meaning making that I could apply relatively quickly and easily to my daughter's other kinds of 'work' (her drawings and writing on paper, the books we read together, the three-dimensional objects that she makes from a variety of materials - beads, boxes, clay, cardboard) could be of any use in understanding this 'world' on the computer screen.

Although the topic of this thesis originated from my interest in children's computer use in the home it evolved to focus on students' use of new technologies in the school. The decision to focus on students' use of new technology in the school (rather than in the home) reflects my interest in school knowledge and practices, in particular, the way in which curriculum subjects are realised differently in different modes and media. Focusing the thesis on technology-mediated learning in the school enables the potential tensions between traditional notions of literacy and learning within formal school education and what it means to be literate in the digital environment of the Twenty-first Century to be explored. There are many differences between children's use of computers in the home and in the school, including that each utilises different media (Facer et. al, 2001; Harrison, et. al, 2001; Somekh et. al., 2001a)ⁱ. Nevertheless, like children at home, students using new technologies in the school are engaged with a range of representational and communicative modes. New technologies that are used in some school classrooms include simulation applications, virtual reality learning environments, electronic books, discussion forum applications, spreadsheets, and hypertext. These applications use a range of representational modes including still image, movement, colour, sound-effect, music, speech (voice) and writing - making both the home and the school equally suitable sites for the purpose of developing multimodal theory and examining the relationship between mode and learning.

The hope of politicians that technology would transform education has not so far been realised, despite the variety of government initiatives to technologise education that have been implemented over the past twenty-five years. The use of new technologies is seen by the government as a primary way to raise standards and to offer more inclusive education. In the last five years the Government has supported information and communication technology in education in England and Wales by providing major funding for hardware, training for teachers, and the National Grid for learning (launched in 1998 and due to continue through to 2004). The government target for all schools to be connected to the internet is near to being realised: by the

end of 2001 99 percent of secondary schools, 96 percent of primary schools, and 97 percent of special schools were connected to the internet (Somekh, 2001a). There is, however, plenty of evidence that schools find it problematic to incorporate ICT into the curriculum. For instance, OFSTED reports indicate that Information Technology is the weakest national curriculum subject. The most frequent use of new technology in both primary and secondary schools is for word processing, producing 'smart-looking' copies of writing – often for display (Harrison et. al, 2001).

The initial enthusiasm for the use of information and communication technology to enhance student learning has been moderated by the effects of the complex issues that have arisen for the effective use of this technology in schools. The usual approach of transposing existing pedagogic practices into a context where new technologies are used has (once again) proved to be inadequate. Research into the attitude and skills of teachers to the integration of ICT has found that some teachers have little confidence, skills, and limited access to resources in relation to new technologies (e.g. Cox 1997). Against this backdrop new technologies are usually fitted into old frameworks for learning in the classroom, they are confined to the relatively superficial, and they are bolted-on to lessons (Becta, 1998; Crook, 1999). Amongst teachers there appears to be a level of uncertainty about their role in the classroom in relation to technology-mediated learning and the majority adopt the role of classroom manager or withdraw (Noss, 1991). Beyond accessing 'information' there appears to be no real sense of how new technologies transform (or might transform) schooled knowledge and learning.

In this thesis I argue that there is a need to understand better how the multimodal semiotic potentials of information and communication technologies mediate learning in general and how these can transform the condition of school learning. This thesis will contribute to developing answers to this question by providing a clearer sense of how the multimodal resources of new technologies reshape curriculum knowledge and practices, as well as the issues that this raises for learning.

Having sketched the purpose of the thesis and given a sense of the interests that it emerged from, in the next section I discuss the research questions that inform it, and the themes that emerged from the analysis and are developed throughout the following chapters.

Research Questions and Themes

The interests and aims outlined in the previous section are addressed throughout the thesis by asking three interconnected research questions.

1. How do the multimodal resources (as they appear on screen) made available by technology-mediated learning shape curriculum knowledge?
2. How does student engagement with these multimodal resources shape school practice (e.g. reading) and what it means to be a learner?
3. What contribution to learning might students' use of the multimodal resources of new technologies make?

The process of applying these three questions to data of instances of technology-mediated learning enables both aims of the thesis to be achieved simultaneously. The analytical process requires the development of multimodal theory to the specific context of technology-mediated learning, and at the same time yields insights into how the multimodal resources of these technologies contribute to the shaping of curriculum knowledge, practices and learning.

Six central themes weave through my analysis and discussion of technology-mediated learning in this thesis. These themes emerged from my initial analysis of technology-mediated learning presented in Part II of the thesis and review of the literature. The

six themes are outlined below and then each theme is discussed more fully. The first three themes focus on the representational and communicational modes of new technology. The second three themes focus on student engagement and practices with such applications.

The first theme is the multimodal character of new technology. I focus on the range of modes used in different applications, and the compositional arrangement of these modes on screen to explore how these shape learning. In particular I show that modes are central to the shaping of curriculum entities, to what it means to be a learner, and to classroom practices. The second theme that I develop in the thesis is the role of language (speech and writing) in many new technology applications. I examine the role of writing and the role of speech as these appear on the computer screen to show that writing is increasingly drawn on as a visual resource and that the role of language is less central to the screen than it has been on the page. The third theme that runs through the thesis is the design of modal relations on screen. I explore how the arrangement of different modes in the applications analysed in this thesis attends to different aspects of the construction of curriculum entities.

The fourth theme I discuss is the need to understand the engagement of students with new technology as multimodal. In order to explore the effect on learning of a range of modes made available via new technologies (as they appear on screen) I analyse the activity of students with new technologies from a multimodal perspective. The fifth theme is the multimodal character of learning. Through the multimodal analysis of instances of technology-mediated learning I explore learning as a complex multimodal activity in which the modes of speech or writing are involved among a number of modes, and show how the multimodal practices of students via technology-mediated learning re-shape practices. This approach questions the notion of literacy as a purely linguistic accomplishment, and highlights the need to re-think what literacy means in a multimodal (and digital) environment. Literacy, what it means to be literate, is the sixth and final theme that weaves its way through the

thesis. I demonstrate that traditional conceptions of literacy are reshaped and expanded in the multimodal learning environment of technology-mediated learning (and elsewhere) and I argue that literacy can more usefully be thought of as a process of multimodal design.

In the following section, in order to situate the thesis clearly in the fields of multimodal theory and technology-mediated learning, I discuss the themes introduced above in the context of the relevant literature.

The Multimodal Character of New Technologies

Representation and communication on the computer screen are increasingly realised through the complex interplay of still image, colour, moving-image, writing, sound-effect, speech, and music. In other words representation and communication on the computer screen are multimodal (Kress, 1998; Kress and van Leeuwen, 2001). Multimodal communication is central to the design and use of the majority of new technologies (such as CD-ROM and Hypertext).

Visual representation is considered especially important, particularly in School Science and Mathematics, as it is thought to make some concepts more easily accessible to students in the classroom, thereby making inquiry and learning 'easier' (Ligorio, 2001). Indeed, visual communication, it has been said, is expanding to the extent that the written elements on screen are now merely what cannot be done in images (Bolter, 1998). Images on the world-wide-web often enter into co-operative relations with words in which images function as 'characters' that link screens. An element's salience on the screen, for example, the use of vectors, symbolic processes, and gaze can draw attention to it as a linking tool.

The multimodal character of new technologies is acknowledged in the field of the usability and design of software and interfaces, although the focus is on the interpersonal level of the 'attraction' and 'appeal' of the interface.

In order to produce a product that attracts and appeals to the target population, a product's visual image, sound, and content all must blend together to provide users with the sensory information that they need to interpret and respond to the program. We are developing information environments.
(Hakansson, 1990: 129)

This computer usability and design literature (e.g. Laurel, 1990; Nielsen, 2000; Shriver, 1997) identifies a number of roles for image, sound, and moving image on the screen. However, it tends to remain at the level of description and the interpersonal and does not give a sense of *how* or *why* different representational modes might function in the way that they do or their role in the construction of information. Nor, most importantly for this thesis, does the literature highlight the potentials of different modes for learning. Nonetheless the literature on usability and design does offer some interesting routes for the analysis I present in this thesis by suggesting the roles that different modes on screen often occupy.

The usability and design literature suggests that still image can be effectively used to highlight overall patterns and trends, to demonstrate complex notions, to depict spatial relations, to depict objects, and to visually create 'mood' and immediacy (Clarke, 1997; Rivlin et. al, 1990). Similarly, colour has been found to be a potentially powerful tool to direct attention, maintain attention, interest and motivation, to increase retention of learning materials, and to show relations between (that is, to link) items (Clarke, 1997). This literature also emphasises the role of modal arrangements on screen and informational structures in screen design (Rivlin et. al, 1990). In particular, elements can be visually grouped or separated through modal configuration, for instance, through the use of colour, brightness, size, shape, type style, spacing, alignment, slope, direction, speed (Rivlin et. al, 1990).

The role of movement (often discussed in relation to the genre of animation) as a resource in interface design is noted in the literature on computer usability and design. Movement, the literature suggests, can be used to display changes over time, to simulate experiences, to show environments that it is not possible to experience, to illustrate interaction between people, and to show depth (Laurel, 1990; Clarke, 1997). The literature on the function of the mode of movement is limited, especially in relation to learning. With a few exceptions, when movement is discussed in the design and usability literature this tends to be at a rather superficial descriptive level. There is a clear need for software and interface design to move beyond the use of animation in the gratuitous enhancement of the interface and to make movement more integral in achieving interface goals. Some research on simulation programs demonstrates that movement can provide students with access to complex phenomena, as well as the opportunity to observe the unobservable and to manipulate models and concepts (Sayeki et al, 1991; Ronen and Liahui, 2000). The potential of animated micro-worlds to demonstrate the differences between everyday understandings of movement and those acceptable to physics in different ways than other technologies has also been shown (Saljo, 1999). However, the role of movement and the other modes made available in these applications is not explored in any detail and the question of how movement might contribute to learning is not explored.

The modal resources of sound are touched on within the computer usability and design literature, although again the focus is on identifying the different functions of sound in applications rather than exploring how sound interacts with other modes on screen, or how it contributes to learning. Nonetheless sound is discussed as contributing to the meaning making resources of new technology applications in numerous ways. For instance the modal resources of sound can be used to create atmosphere, give warnings, to gain the attention of the user, and to convey other meanings. Sound is also used to communicate information about physical events (e.g. glass dropping), invisible structures (such as a tap on a wall), dynamic changes (e.g.

liquid reaching the top of a glass), or to show events in space (like the use of footsteps to indicate social distance) (Mountford and Gaver, 1990).

Semiotic theory has been applied to new technology, principally in the fields of graphical user interface design (Callahan, 1994) and human computer interaction (Andersen 2000; Nadin, 1985). Indeed Nadin argues that human computer interaction *is* semiotics applied. This work has attempted to mobilise semiotics in the characterisation of human computer interaction through viewing the relationship between software designer and user and seeing the interface as the linking medium (Laurel, 1990).

There has been some research into the multimodal character of new technology within social semiotics that does begin to explore the potential role of modes in meaning making but to a lesser extent learning.

The semiotic character of hypertexts and hypertext links are discussed in this literature. Lemke explores the potential of hypertext to realise new interactions between word, image and sound (Lemke, 2002). In particular the multiple combinations of resources within hypertext can provide a resource for the construction of meaning relations between modes on web-site screens. The semantic functions of links in hypertexts have been explored and classified by Harrison (2002) as authorizing, commenting, enhancing, exemplifying, referencing/citing, or self-selecting information on screen. The meaning of the structure of a CD-ROM are analysed by van Leeuwen (1998) who concludes that:

The structures of such interactive texts are modelled on, and can themselves provide models for, social cohesion and interactivity.
(van Leeuwen, 1998: 119)

The analysis of the structure of an interface is therefore one way to bring the ideology, hidden agenda or curriculum of an application into the 'open'. The way in which image, writing, sound and video are designed to actualise information and ideology in CD-ROMs has also been explored (Zammit and Callow, 2000). These papers offer interesting insights and starting points for the social semiotic analysis of new technologies in this thesis. However these papers and indeed the majority of work from a semiotic and social semiotic perspective tend to focus on the resources of the computer screen as a text and do not explore what happens when users engage with these resources. There are a few notable exceptions to this, for instance in their analysis of a short animation made by secondary school students Burn and Parker (in press) explore the students use of the resources of digital drawing and animation software in media education.

One of the goals of my thesis is to contribute to a better understanding of how the design and ideological positions of multimodal texts as they appear on the screen might influence, shape and reshape, people's use of them. To this end I argue for the need to look not only at the screen as a text but also to look beyond the screen to the practices of students.

The De-centring of Speech and Writing

It is almost a cliché to say that the form of a sign shapes its meaning but 'the medium is the message' (McLuhan, 1967) is a slogan which is all the more pertinent in the context of new technologies. This relationship between form and meaning is apt and crucial because the multiplicity of representational modes that most computer applications make (easily) available demand an answer to the question of what mode to use, and when. Although the continued role of writing in these multimodal texts is not in question, they do raise important issues regarding the choice of the mode used (image, word, sound, etc.) (Lanham, 2001). The need to understand the communicative and representational potential (the affordances and commitments) of

image, writing and movement, and so on, as they appear on the computer screen is increasingly recognised as central to learning (Lankshear et. al, 2002).

Writing on the computer screen (and other screens including the mobile phone screens, game boys and so on) appears to be regaining its visual character, its image-quality (Lanham, 2001; Elkins, 2000). Indeed it has been stated that:

We are entering a historical epoch in which the image will take over from the written word.
(Gombrich, 1996: 41).

While this prediction may be as ‘off the mark’ as predictions that computers heralded the demise of the book, visual communication does appear to be increasingly foregrounded in educational texts - whatever the technology. The increased use of visual and other modes of communication is epitomised by (but not restricted to) new technologies.

Theories of the relationship between word and image include the potential for images to extend the meaning of words (i.e. ‘relay’), or to be independent of them (Barthes, 1977). The dominant theory of the relationship between word and image had been one of ‘anchorage’ – in which words anchor the meaning of an image (Barthes, 1977). The complexity of the relationship between image and word in the multimodal environment together with the increase in visual communication that is entirely free of words suggests that in many cases a view of image as reliant on word is no longer relevant (van Leeuwen, 2000).

The multimodal character of new technology and the consequential ‘de-centring’ of the modes of speech and writing, suggests that research which focuses on these modes alone will fail to examine much of what goes on in technology-mediated learning (both on and around the screen).

Multimodal research on the construction of School Science and English shows that even in classrooms where speech is in the foreground a wide range of modes contribute to the construction of knowledge and the processes of learning (Kress et al., 2001; SEP 2002; Bourne and Jewitt, in press). It shows that speech and writing are not always central to teaching and learning and the meanings made through speech and writing rely on the other modes that they are embedded within (Jewitt et al., 2001). In this thesis I argue that the exclusive focus on language in technology-mediated learning serves to maintain the centrality of speech and writing in the analytical process. I suggest that ignoring (negating) the multimodal character of technology-mediated learning results in a failure to grasp the potential impact of new technologies on teaching and learning.

The Interaction of Modes on Screen

When several modes are involved in an event of communication then all of these modes together will represent significant aspects of a message's meaning (e.g. Kress et al., 2001; SEP, 2002). The meaning of a message is distributed across all of these modes, and not necessarily evenly. In short, different aspects of meaning are carried in different ways by each mode. Any one mode in that ensemble is carrying a part of the message only: each mode is partial in relation to the whole of the meaning – and speech or writing are no exception (Jewitt and Kress, 2002a). Attending to the interplay between modes is therefore important as each mode interacts with and contributes to all others. At times the meanings realised by two modes can be 'equivalent', they may be complementary, where one mode 'repeats' information presented in another. At other times each mode may refer to quite different aspects of meaning or the two may be contradictory (Lemke, 1998a). An analysis of how image and writing in sexual health leaflets for young heterosexual men, for example, shows that different discourses of male sexuality were realised modally (Jewitt, 1999). A positive discourse of male sexuality was realised in the mode of writing that focused on shared responsibility and emotion. The discourse realised visually was however

extremely negative, it portrayed young men as predatory, sexually irresponsible and dangerous. In short, the visual and written discourses in the leaflets stood in stark contrast to one another and attended to the realisation of two distinct discourses of masculinity. The discourse of masculinity that could be 'legitimately' (socially and professionally) expressed and was realised in written mode, while the discourse that could not be legitimately expressed was realised visually.

Multimodal Engagement with New Technology

Within the literature on technology-mediated learning there is work that shows how computers organise classroom talk into distinctive patterns of interaction. For example, Mercer et al. (1999) identify three kinds of talk in the context of collaborative computer work - disputational, cumulative and exploratory, and suggest that each offers different ways of thinking and different potentials for learning. The role of computers in the construction of shared meaning has also been investigated (Wegerif and Scrimshaw, 1997). In particular the role of computers on the joint construction of understanding and the negotiation of meaning in collaborative problem solving has been examined (Looi and Ang, 2000). Research on collaborative learning highlights the potential of computers to mediate (new forms) of social interaction between students, and between students and teacher in the classroom and to create new learning environments (e.g. Healy, Pozzi, and Hoyles, 1995; Littleton and Light, 1999; Crook, 1990; Hoyles et al., in press). However, this research focuses almost exclusively on talk.

The introduction of new technology to learning has the potential to reshape student and teacher roles and their relationships to knowledge (Russell, 2002; Morgan, et. al., 2002). More specifically it is widely suggested that new technologies can increase the control of the learner and decrease the authority of the teacher. An interest in collaboration and social relations in the classroom has led to much research on the organisation and use of computers, much of which highlights the increased cognitive resources and skills available when students work in pairs and triads (Crook, 1999;

Littleton and Light, 1999). This work has led to dialogic and collaborative principles in relation to technologies in education and the assertion that new technologies need to be understood in terms of mediation rather than transmission. The analytical focus in the majority of this research is on linguistic interaction - talk around the screen.

Some research has attempted to combine an interest in the practices and interaction of students and the resources on screen. Building on research into the distinctive patterns of interaction and talk some research studies have explored how the different structures embedded in computer software affect talk (Baxter and Preece, 1999; Anderson et. al, 1999). Nonetheless the analytical approach to screen remains rooted in language – either spoken or written, and the multimodal resources of screen rarely come into the realm of the analysis. The structure of computer applications is, however, one area that has received some attention in this field. For instance, computer learning programs with open and closed task structures have been shown to affect patterns of collaboration and interaction differently (Anderson et. al, 1999). Computer characters and interventions have been designed in order to mediate specific kinds of talk between students (Mercer and Wegerif, 2002). The ways in which different structures of interactive multimedia can be designed to impact on user autonomy, pupil motivated avenues to learning, and to support essential aspects of learning has also been examined (Plowman, 1996a; Plowman, 1996b; Laurillard, 1998).

The 'creative' potential of computer applications (e.g. web design and animation) in learning has been the focus of much cultural and media studies research (e.g. Sefton-Green and Parker, 2000; Buckingham, 2000; Lachs, 1999). Much of this work focuses on technology use outside of formal educational sites. The ways in which young people's engagement with new technology can give expression to young people's self-identities (Turkle, 1995; Sinker, 2000), and youth culture more generally (Nixon, 1998) has been a subject of study. Within the school context the 'creative' potential of new technologies and the lack of prescriptive assessment criteria of what

is 'good or bad mark making' and 'design' has been shown to increase pupil motivation (Lachs, 1999; Sinker, 1999) and to improve the 'quality of learning'.

Multimodal Learning

The multimodal character of technology-mediated learning, the 'de-centring' of language, and the interaction of modes as they appear on the computer screen all raise important questions for what it means to interact with the resources of new technology and learning more generally.

Learning, especially school learning, is usually understood as a linguistic accomplishment. Language (speech and writing) is seen as central to communication in general and learning in particular. In part this is because language has been considered the only fully articulate means of representation. It is considered fundamental to thinking, and therefore to rationality, in which talk is a social mode of thinking (Mercer, 2002). That is, everything that can be thought can be thought in language, and everything that can be represented, can be represented in language. From that theoretical perspective other forms of communication have been characterised as either irrelevant or merely supportive of language.

Many commentators have, however, pointed out that visual communication in learning is increasingly prevalent (Messaris, 1994; Sharples, 1998; Buckingham, 2000; Kress and van Leeuwen, 1996, 2001). I argue in this thesis that looking at learning through a multimodal lens to account for all modes does not offer a 'better' view of the 'same' picture carried in language (speech and writing) - it offers a different view.

Others have heralded the potential of new technologies to act as a tool to think with that can effectively reshape learning, teaching, the classroom and ultimately the school (Papert, 1993; Resnick, 1995). This literature suggests that new technologies can offer models and metaphors that have a significant effect on how people think

about and make sense of the world. From this perspective, computer 'intelligence' is seen as radically extending and altering what people think of as human imagination, intelligence, problem solving skills, and the capacity to see our own thoughts in action and replay them for our reflection. The potential of computers to reify or to 'make concrete one's own thinking, and to do so in a manner that has never before been possible.' (Sewell, 1990: 21) places new technologies in the role of 'liberator' giving the learner more independence and reducing mental drudgery. This research acknowledges the multimodal potential of new technologies, but does not ask how its multimodal character might contribute to learning.

Many claims and predictions have been made about the power of new technologies to change learning – and the world. However some computer applications provide little that is new for learning and teaching. The replication of formalist approaches to the arts in paint box applications, for instance, continues to focus on line, tone, and colour and in doing so replicates traditional teaching in a new medium (Sinker, 2000). The traditions of 'drill and skill' rote learning are embedded in the design of much current educational software (e.g. success maker), which breaks the desired learning goals into small steps and relies on reward, repetition, and contingent incrementation of difficulty levels to impart skills (Littleton and Light, 1999). While the conditions for learning can be improved by new technology in the classroom, it is clear from the literature that this potential is not always realised. Indeed, Davis and colleagues (1997) comment on the potential for teachers to use new technology to 'create a new set of mundane tasks' that fail to make use of the opportunities for learning offered by new technologies.

The question of how the multimodal character of new technologies can be used effectively in learning remains unanswered. One reason for this, I want to suggest, is the tension created by the multimodal character of new technologies and the desire to maintain language at the centre of the school curriculum. This brings into focus the question of literacy and what it means.

Multimodal Literacy

Government educational policy (e.g. The Literacy Strategy and the National Curriculum) does not address the problematic and contentious character of literacy and the struggle over its meaning (Brookes and Goodwyn, 1998). While recent government initiatives seem determined to focus on the concept of literacy in its most restricted sense, outside of the school young people are “ ‘reading’ and ‘writing’ across a new terrain, redefining what literacy might mean.” (Raney, 1998: 37). In this thesis I argue that there is a need to conceptualise literacy more broadly as a matter of multimodal design.

While the visual and the linguistic can be treated as distinct versions of literacy to be attended to, that is visual literacy and written literacy, what is needed I argue in this thesis is not the addition of the visual but the re-thinking of the whole complex of representation. Kress (2000) argues for the need to have a concept of literacy as a multimodal process in which all modes are critically interpreted, and their interactions considered. This leads to a shift from a conception of competence in literacy to one of literacy as multimodal 'design'. There is a need for a means of talking about this 'new literacy' about what we do when we read and produce images (Kress and van Leeuwen, 1996). New technologies make available a whole range of multimodal possibilities for individuals' production of documents (layout, colour, scanned images, use of tables, word art, sound, and so on) and allow new kinds of 'reading' of texts (Burn and Reed, 1999). The learning processes when working with new technologies require 'substantially different literacies' which relate to the different character of texts that students need to work with (Downes and Zammit, 2000). To continue to think of learning only in terms of writing and speech is therefore problematic.

As images are a central part of the communicative environment it has become increasingly important to be able to 'read' images. In '... a media-text, and symbol

saturated environment', it is important to be able to 'construct, control, and manipulate visual texts and symbols' (Luke, 1996). The ability of flexible, interactive fluid hypertext to redefine reader, author, and text relations (as the reader constructs the text in reading it) this demands new ways of thinking about forms of literacy, new skills of linking, decomposing, reorganising elements (Bolter, 1999; Lemke, 1998b; Beavis, 1998). New technologies bring-forth different kinds of cultural forms (e.g. computer game, cyber-linked web-site) and have changed some existing cultural forms (such as sampling - non-linear editing). All of these demand an expansion of traditional notions of literacy. Sefton- Green and Reiss (1999) argue that this should include:

... an ability to work across text, image, sound and moving image with equal fluency, exploiting each dimension separately and making connections between these historically discrete domains.
(Sefton-Green and Reiss, 1999:2).

Many of these skills already exist in the realms of work and education; what is new is the speed and ease at which these tasks can be conducted, and the technological environment in which they are facilitated (Lemke, 1998b).

A multimodal approach to theories of literacy stress communication through a wide range of forms and materials; the agency and interest of individuals in the making of messages; and genres and other forms to be reshaped (Anderson et al., 1999). What it means to be literate is, I argue, becoming increasingly 'complex and elusive' (Beavis, 1998).

The Contribution of this Thesis

This thesis contributes to both the field of technology-mediated learning and the area of multimodal theory.

It contributes to the field of technology-mediated learning in three ways. First, the thesis moves beyond talk in order to account for the complex relationships between representational and communicational modes in the construction of meaning and learning. Second, the thesis focuses on literacy as a multimodal concept and asks what it means to be literate in across the school curriculum in a digital era. Third, it contributes to a better understanding of how the multimodal character of new technologies re-mediate school knowledge and practices.

The thesis contributes to the development of multimodality in two ways. First the thesis moves beyond the text to analyse people's situated practices with texts, and the relationship between text and practice. Second, the thesis expands multimodal theory beyond the page into the domain of the screen. Third, the thesis offers a coherent approach for looking at a range of modes and the interaction between them on screen.



For the reasons outlined in this chapter I approach technology-mediated learning from a theoretical perspective that moves beyond talk – a multimodal social semiotic perspective. This theoretical approach is described in the following chapter, Chapter Two. The application of multimodal theory to technology-mediated learning is the focus of Chapter Three.

ⁱ On average children spend three times as long on computers in the home as they do in school (Harrison, et. al, 2001). During this time they are engaged in more challenging and innovative uses of new technologies than in the school (Somekh et al., 2001a).

2. Turning a Multimodal Lens on Technology-Mediated Learning

Introduction

In order to understand the relationship between the multimodal semiotic resources that new technologies make available in the classroom, and knowledge, literacy, design and learning, I turn to social semiotic theory as it theorises the relationship between semiotic resources and people's meaning making. Halliday's (1978) social semiotic theory focuses primarily on the semiotic resources of language (speech and writing). However, I argue that the prominent role of visual semiotic resources on the computer screen (and elsewhere) and the multimodal character of learning requires a theory of meaning making that moves beyond language. For this reason I take a multimodal approach to the analysis of technology-mediated learning which builds on the theoretical concepts of social semiotics in order to account for the semiotic resources of a range of modes including still image, colour, animated movement, writing, sound-effect, and speech.

While social semiotic and multimodal theory offer conceptual tools for the analysis of meaning making, the theoretical focus is on 'semiosis'. As such the socially situated nature of meaning making in schools is not foregrounded. The rules and norms that underpin meaning making in schools and the traditions and histories that are embedded in curriculum and subject knowledge are not clearly in their analytical domain. In order to give due attention to the socially situated character of meaning making I theorise multimodal semiotic mediation within the analytical framework of activity theory. In order to focus on specific instances of 'formal' learning I focus on school, pedagogy and curriculum.

In bringing together the concepts of multimodality and activity theory my intention is to reconfigure both of these theoretical approaches in significant ways for learning. By focusing on the multimodal resources of screen and the multimodal character of learning more generally I challenge activity theory to look beyond language. I argue that the semiotic resources of a range of modes, a multimodal ensemble of which language (speech and writing) is only a part, shape semiotic mediation and the process of internalisation. In moving beyond the individual sign maker to understand meaning making as situated within a system of activity (in this thesis the school classroom) I refocus multimodality by ‘filling in’ the social and historical forces that underpin and shape learning.

In this chapter I address four points. First I discuss the way in which social semiotics theorises meaning making as a relationship between the social and ‘semiotic resources’, a concept that is central to social semiotics and to this thesis. Second, I describe how a multimodal approach expands the concept of semiotic resource to a range of representational and communicational modes beyond language. Third, I argue that combining a multimodal social semiotic approach and activity theory offers a better understanding of the dynamic social relationship between sign, the agency of the sign maker, semiotic resource and the social context of making meaning. Fourth, I then discuss the ways in which these theoretical concepts inform the view of learning taken in this thesis.

Multimodal Meaning Making

For Halliday (1978), whose focus is on language, a semantic system is shaped by the social functions of the utterance (sign) as representation, as interaction, and as message. He calls these three social functions metafunctions. These metafunctions are meaning potentials, what can be meant, what can be done. According to metafunctional theory language simultaneously realises three kinds of meaning: ideational meaning, which functions to construct representations of the world, interpersonal meaning, which characterises specific social relations, and textual meaning, which

functions to marshal communicative acts into (communicative) texts that realise specific social practices. These three kinds of meaning functions are held by the grammar and by the words (the Lexical-grammar) of language.

Social semiotic theory was developed in relation to language and has until recently focused almost exclusively on speech and writing, with a few notable exceptions (Hodge and Kress, 1988). Multimodality extends the concept of metafunctions beyond language (speech and writing) to all communicative modes. It asserts that through the cultural shaping of the affordances of modes in the work of semiosis distinct and different potentials for meaning become developed in all semiotic modes (speech, gesture, visual communication, music, and so on). The need to understand the meaning of speech and writing in their multimodal context has however been acknowledged, such as the potential of gestures to contribute to a holistic picture of communication (Halliday, 1978: 37). Recently social semiotic research has begun to take account of modes and systems of making meaning other than language, including music, speech and sound (van Leeuwen, 1999), action (Martinec, 2000), as well as visual communication (O'Toole 1994; Kress and van Leeuwen, 1996). Most recently, work in the Hallidayan functional linguistic tradition, and in social semiotics, has increasingly viewed the social production of systems of signs and meanings as a multimodal phenomenon (Kress et. al, 2001, Kress and van Leeuwen, 2001; Martin and Veel, 1998; Baldry, 2001).

Meaning making starts in production with the interests of the sign maker as they are configured in a specific social context and moment in time. Meaning making can be understood as the interaction between the socially situated interest of the sign maker and the potentials for meaning (what it is possible to mean) with the resources available to them and their realisation in specific representational and communicational acts (signs). In other words on the one hand there is the socially situated interests of the sign maker, the meaning potential of the semiotic resources of a mode, what can be meant in a particular semantic mode, and on the other there is

the realisation of meaning through modes. While modes have different potentials for realising meaning all modes are resources available to realise meaning, all modes can represent the world, represent interactions, and can be used to form messages. The representational and communicational affordance of modes is the outcome of complex social shaping of the materiality of modes in their social usage (resulting in functional specialisation and load) and the designed relationships between modes.

Mode

A mode can be thought of as any regularized organized set of semiotic resources for articulating meaning. Modes are broadly understood to be the result of the effect of the work of culture in shaping material into resources for representation. These resources display regularities due to that cultural work and due to their more or less frequent use in social (inter) action. The more work a culture has put into such a resource, for whatever reasons, and the more it has been used in the social life of a particular community, the more fully and finely articulated it will have become. Through this use the semiotic resources of modes come to have regularities of use. These regularities are what have been called ‘grammars’ traditionally.

For instance, the resources of the visual mode (e.g. diagrams, pictures, icons, and symbols) offer a collection of potentials or resources for making meaning. These include the depiction of participants, vectors, setting – the type and the degree of contextualisation, visual props, the use of angle and perspective, detail or absence of detail, depth, the position of elements in space, salience, and framing. Through people’s use of them these resources have come to have meaning. (The semiotic resources of still image, colour, animated movement, gaze, and so on, are discussed in detail in Chapter Three.)

Materiality

Materiality is the physical character of that what a culture provides as materials for making meaning. Materiality is everywhere and the physical materiality of a resource

comes to have meanings as a culture selects and draws these into meaning making. These materials (e.g. sound and light) have qualities that affect how they can be culturally shaped into modes, how they can realise meanings. The materiality of a mode contributes to how a mode is shaped through people's social use of it; and this has led to the concept of modal affordance.

Modal Affordance

The affordance of a mode can be understood as what it is possible to express and represent readily, and easily with a mode given its materiality and given its cultural and social history – what it has been used to do (mean). Where a mode 'comes from' in its history of cultural work, its provenance, is understood by members of that culture, and becomes a part of its affordance. The affordances of image, in the form of graphic marks on a two-dimensional surface for example, offer different potentials for the expression and representation of meaning than the affordances of speech, in the form of sounds over time. The specific semiotic resources of modes are 'essentially incommensurable' (Lemke, 2002).

No [written] text is an image. No text or visual representation means in all and only the same ways that text can mean. It is this essential incommensurability that enables genuine new meanings to be made from the combinations of modalities.
(Lemke, 2002: 303)

The question of what image is 'best' for, and what words and their arrangements are 'best' for, is raised by the concept of affordance (Lanham, 2001). Each mode possesses a specific logic and provides different communicational and representational potentials (Dicks and Mason, 1998; Jehng et. al, 1999). The sounds of speech for instance happen in time, and this sequence in time shapes what can be done with (speech) sounds. The logic of sequence in time is unavoidable for speech: one sound has to be uttered after another, one word after another, one syntactic and textual element after another. This sequence is an affordance: it produces the

possibilities for putting things first or last, or somewhere else in a sequence. The mode of speech is governed by the logic of time. (Still) images are governed by the logic of space and simultaneity. A sign-maker has to display what they wish to show in the space available for their representation, be it the page or the screen. All of the elements that they wish to display have to be simultaneously present, and their relations in meaning have to be spatially indicated: close to or far away, below or above, centrally or marginal. Modal affordances are used differently in different communities of practices, they have come to be shaped differently through their social use in specific communities of practices. The resource of modes and their affordances has led to the functional specialisation of modes.

Functional Specialisation

Functional specialisation of modes is a feature of multimodal representation: it is an effect both of the affordances of modes (i.e. this mode is can more easily represent something than another mode can), and of design decisions in relation to the audience. Such design decisions include the effect of power, as when the elite make a mode into the preferred resource as has been the case with the mode of writing. The specialisation of modes refers to the long-term effect of cultural valuation: if a culture values a mode highly, much work will inevitably go into its elaboration, through its constant use by members of a social group. Its constant use in relation to specific purposes will make modes come to be specialised for representing and communicating particular meanings in particular social contexts. As a result not every mode will be equally 'useable' for a particular task:

It is possible to envisage the whole field of everything that can be 'meant' in a given sociocultural domain at a given moment of its development (which, in my view, is not co-extensive with the semantics of language) and then to also envisage how that sociocultural domain will have a certain distribution of different semiotic modes across that field, in such a way that some things can be signified visually as well as verbally, others only visually, others only verbally, others both verbally and musically but not visually, and so on.

(van Leeuwen, 2000: 181-2)

Functional Load

Functional load of modes is related to, but distinct and (independently variable) from, functional specialisation. The term functional specialisation of modes refers to how modes are shaped by societies' usage of them to realise particular kinds of meaning, at a *general* level. The term functional load of modes refers specifically to the use of a mode in a *particular occasion* of communication: whether most of the informational load is carried by speech, by image, or by gesture or by all three modes together (Jewitt et. al, 2000). On a computer screen the curricular content (depending on the school-subject at issue) might be carried by writing (i.e. the functional load would be on the mode of writing) or by image, or it might be distributed evenly between the two.

I use the concept of functional specialisation and load to explore how modes in technology-mediated learning realise particular kinds of meaning, when modes are used and what they are used for.

The Designed Interaction of Modes

Modes never occur alone in a text (Kress and van Leeuwen, 1996). Even the practices of writing and reading are multimodal practices, drawing on visual and actional modes in particular the resources of spatiality and directionality (Kenner, in press). How modes are orchestrated to make meaning is therefore central to a multimodal approach. In any communicational event one mode may be foregrounded and others not. Within a multimodal approach to communication an assumption is that any mode may become foregrounded or backgrounded. The foregrounding of different modes in the multimodal ensemble shapes curricular knowledge in particular ways.

More recently Kress and van Leeuwen (2001) have argued that rather than focusing on the semiotics of one mode (such as visual semiotics in their earlier work) there is a need to explore the principles that stand behind multimodal communication:

We move away from the idea that the different modes in multimodal texts have strictly bounded and framed specialist tasks, as in a film where images may provide the action, sync sounds a sense of realism, music a layer of emotion, and so on, with the editing process supplying the 'integration code', the means for synchronising the elements through a common rhythm (van Leeuwen, 1985). Instead we move towards a view of multimodality in which common semiotic principles operate in and across different modes, and in which it is therefore quite possible for music to encode action, or images to encode emotion.

(Kress and van Leeuwen, 2001: 2)

Kress and van Leeuwen (2001) put forward four interconnected semiotic principles for consideration in multimodal analysis including discourse, design, production, and distribution. I draw on these as analytical tools throughout the thesis.

Discourse is used to refer to 'socially situated forms of knowledge about (aspects of) reality' (Kress and van Leeuwen, 2001: 20). Different discourses are available to people in relating a particular event and they use the discourse that is most apt to express their interests in the communicational situation that they are in. These discourses construct knowledge through the inclusion and exclusion of participants and events, and the links that are made with other events and discourses. Discourses can only be realised in semiotic modes and this introduces the concept of design.

Design is a process that stands between content and expression and is used to refer to 'conceptualisations of the form of semiotic products and events' (Kress and van Leeuwen, 2001: 21). Design involves the formulation of discourse in a particular social context through the combining of semiotic modes in a particular way. In short, design is the means for the realisation of discourse and is separate from the actual material product.

Kress and van Leeuwen use the concept of Production to consider 'the articulation in material form of semiotic products or events' (Kress and van Leeuwen, 2001: 21). It

is the material semiotic organisation and expression of the design in the form of a communicative event or text. The design is itself transformed in the production via the meanings brought forth by the process of articulation and the semiotic resources of the materials and modes that are used.

Alongside production stands Distribution, ‘the technical ‘re-coding’ of semiotic products and events, for purposes of recording (e.g. tape recording, digital recording) and/or distribution (e.g. radio and television transmission, telephony)’ (Kress and van Leeuwen, 2001: 21). The point made here is that the process of distribution (the medium) is semiotic and can add additional layers of meaning in the way that a song for instance is technically recorded. The distribution of worksheets or images in schools is an interesting example of the semiotic character of distribution. As people photocopy and pass them on the image-quality deteriorates, details are lost, colour becomes grey scale, images are transformed, page numbers and the origins of worksheets are slowly removed by the hasty positioning of papers in the machine and so on. In other words, the medium of a ‘message’ shapes the semiotic potentials it makes available and how these are actualised:

Technology enters fundamentally into the semiotic process: through the kinds of meaning which it facilitates or favours, and through the differential access to the means of productions and reception which it provides.
(Kress and van Leeuwen, 1996: 233)

The facilities of new technology, discussed in Chapter Three, are drawn into the analysis of the thesis.

Semiotic Resource

A key distinction between traditional semiotics and social semiotics lies in the distinction between semiotic ‘resource’ and ‘code’. Semiotic systems are traditionally seen as the basis of a code, sets of rules for connecting signs and meanings. Once two

or more people have understood the same code they would therefore be able to connect the same meanings to the same sounds or graphic patterns, and be able to understand each other. In such theories of sign, the semiotic system is simply 'there'. It can be used but it can not be changed in any way. The starting point for social semiotics is meaning. Signs are viewed as the product of a social process of sign making in which the signifier and signified are independent of each other, rather than understanding the sign as a pre-existing conjunction of a signifier and signified, an element in a code, to be understood and used. The sign maker brings signifier and signified together to make a sign. Sign makers have a meaning (the signified) which they want to express and they express it through the most apt semiotic resources available to them at that moment (the signifier).

The concept of semiotic resource and the process of sign making can be exemplified by an instance drawn from two students designing a computer game (discussed in Chapter Five). In the design of their game the students use the semiotic potentials of visual difference, size, and movement to visually signify the weakness of one character in relation to another. The students' sign making is a matter of selecting the signifiers that they consider most apt to express the vulnerability of the character. In the initial design stage of their game the students talk of a 'little figure' that will be caught by an alien. The resources of the computer application (Toontalk) that they use to build the game provide the students with different options or semiotic potentials for representing the little figure and the other elements of the game. The students select an image of an alien from the Toontalk notebook (the notebook is a collection of multimodal resources, images, sounds, animated movements, and so on), and an image of Jupiter for game background. They now need to find a form for the little figure. They select a small flying dog with a rocket on its back. The choice of a dog, a familiar pet, as opposed to a small alien serves to mark the figure's difference to the alien and the planet. This signifies the outsider status and potential weakness of the little figure. Size is a semiotic resource that is easy to change in Toontalk suggesting that the students kept the dog small to signify its vulnerability.

The dog is programmed to move from side to side, a restricted movement that again signifies its weakness. The students use the most apt signifiers available to them (in this case through image and animated movement) to realise the meaning they want to express, that is the vulnerability of the character. As this example demonstrates the distinction between code and resource has implications for the understanding the agency of sign makers and the concept of sign.

To map the meaning potentials of language Halliday (1978) uses a style of diagramming called 'system networks'. These system networks map the meaning potentials of semiotic resources and the relations between them. System networks have been used to explore the resources and the 'grammar' of visual communication (Kress and van Leeuwen, 1996), sound (van Leeuwen, 1999), and action (Martinec, 2000). This work theorizes the networks of semiotic alternatives from a variety of communicative modes that constitute the multimodal meaning potential of a culture, that is, what can be meant.

The ideational metafunction of a semiotic system enables people to construct representations of 'what goes on in the world': their experience of the world (external and internal). The linguistic resources for doing this include words, which 'stand for' the 'participants' (people, places, things in the world), and the system of transitivity, which enables the creation of different relationships between these participants, in terms of actor and goal, reactor. Kress and van Leeuwen (1996) have extended the ideational metafunction to analyse visual representation and communication. Ideational meanings can also be realised through the semiotic potentials of the resources of gesture (Jewitt and Kress, 2002a), gaze (Lancaster, 2001), movement (Martinec, 2000), animated movement (Burn and Parker, in press), music (van Leeuwen, 1999) and so on.

The interpersonal metafunction of semiotic systems constitutes and enacts relations among the people involved in a communicative event, such as the role adopted by the

producer of a sign, and assigned to its receiver. That is, the semiotic system has to project a particular social relation between the producer, viewer, and the entity represented. The linguistic resources for doing this include the system of inclusivity and exclusivity, the system of mood with which you can make statement (declarative), ask questions (interrogative), tell people to do things (imperative) etc. These metafunctional meanings are realised, even though differently, through visual communication, action, music, and so on.

The textual metafunction structures the message in relation to the total communicative event; it organises the ideational and the interpersonal into texts. The linguistic resources for this include the given/new system, resources for creating cohesion in text. Visually, different textual meanings can be realised through compositional arrangements and the use of framing (Kress and van Leeuwen, 1996). As with the other modes the cohesion and coherence of texts can be realised through the rhythm of sound (Burn and Parker, in press; van Leeuwen, 1999), and the pace and rhythm of image.

Halliday and other systemic functional linguists tend to view the metafunctions and corresponding system networks as mapping *the* potentials for making meaning, what can be meant. The potential of a theory, any theory, to map all of the complex ways in which people make meaning given the dynamic and changing character of meaning making is questionable. I use the concept of metafunction as a conceptual tool to think about meaning, semiotic resources and meaning potential in order to ask what kind of communicational work different modes on the computer screen (and elsewhere) do and how. In this way, I use the metafunctions and the corresponding system networks as a 'map' (in the broad sense) of possibilities and combinations, a sketch or backdrop to meaning making, rather than a blue-print of the meaning potentials available to all people. From this position, I view system networks as a 'snap-shot' of the meaning making potentials that people are acculturated into. (Like all 'snap-shots' of an evolving process system networks are partial.)

Sign

The concept sign informs the analysis of technology-mediated learning presented in this thesis. Building on the concept of sign in social semiotic, multimodal and activity theory I view signs as motivated, transformative and mediating social interactions in the material world that shape consciousness or 'mind'.

Motivated Sign

Traditional Saussurean semiotics theorizes the relation of meaning (signified) and form (signifier) as conventional and arbitrary (Saussure, 1974). From this perspective there is no intrinsic connection between the meaning and the form used to express it: people are regarded as confronted with ready-made systems for making meaning. Theorizing a sign system/mode as a code in which the rules fixed in advance determine the process of sign making, rather than the selections or interests of people, excludes the action of an individual agent. The agency of the sign maker is limited, she or he can use the system but can not change it. The theorization of sign makers as 'outside' of the system of communication in traditional semiotic led to the distinction between 'langue' and 'parole' in which langue refers to the abstract potential of a semiotic system and parole refers to the particular realizations of the potential of langue. The ways in which people actually use language were rejected by traditional semiotics as too individual an object of theory, and as a consequence the analytical focus is primarily on language as a system and how the elements afforded in language are structured.

Social semiotics does not make a distinction between langue and parole, a distinction which it views as artificially separating the social from the individual and one that 'cuts off semiosis from society, and semiotics from social and political thought' (Hodge and Kress, 1988: 2). Social semiotics loosely re-frames langue as the 'potential for use', sets of semiotic alternatives that differentiate between elements so as to reflect the social functions of a sign and parole as individual acts of sign



making. Social semiotic theory argues that people do not have direct access to language (and other modes) as a system, rather that the meaning of signs is made by them in contexts. Sign use is a process of people's choices from a network of choices: in which the sign maker selects one resource (meaning potential) over another (Halliday, 1978, 1985). The receiver of a sign, in the process of interpreting it, is also involved in this selection of meaning potentials as she or he re-makes the sign. Meanings are realised through the selection of meaning potentials from the networks of options offered by modes in specific contexts. This highlights the agency of the sign maker as she or he is involved in selecting the most apt signifier for their signified in a particular context. From such a perspective the relationship between signifier and signified can no longer be theorised as an arbitrary one. Signs are understood as motivated by the interest of the sign maker and the social forces operating on them.

People's choice of semiotic resources (meaning potentials) in a specific context is shaped by their individual social experiences and their acculturation into the social conventions of society – in other words the choices people make are socially constrained. Nonetheless, there is some freedom of choice depending on the social context, the power of the sign maker, the sign-maker's 'willingness' (or power) to bear the consequences of resisting convention, and the degree to which the sign maker has been inducted into these conventions.

There are many common-sense examples that support the argument that signs are arbitrary and these are challenged by the theorisation of the motivated sign. For instance, Kress argues that Wittgenstein's scenario of a button standing for a lost pawn in a game of chess proving the possibility of substitution of one signifier for another is problematic (Kress, 1997:92). If five chess pieces of different game value were lost he suggests that they could not be substituted with five buttons of equal size. A distinguishing feature such as the size of the buttons would be needed in order to signify the different values of the chess pieces. The players could then establish the

convention that size will signify value. In other words, the relationship between meaning and form is motivated and nonetheless draws on resources shaped by convention.

The choice of one semiotic resource over another raises the question of what motivates a sign maker's choice of semiotic resource. The concept of the 'interest' of the sign maker is developed by Kress (1993) in response to this question:

'Interest' is the articulation and realisation of an individual's relation to an object or event, acting out of that social complex at a particular moment, in the context of an interaction with other constitutive factors of the situation which are considered as relevant by the individual.
(Kress, 1993:174)

The concept 'interest' formulates motivation as the relation of the sign maker to the social context of sign production, which includes the potentials of the modal resources that the context makes available. In this way social semiotics shifts the focus from modal system to the process of meaning making (signs). The concept of interest theorises the relationship between signifier and signified as a trace of the characteristics of the producer of the sign (as a socially located person) and the entity to be represented. The sign is a product of the complex interaction of the sign maker's 'physiological, psychological, emotional, cultural, and social origins' (Kress, 1997:11). It is the sign maker's 'interest' that, according to Kress, leads to the selection of criterial aspects of the signified and specifies the characteristics of 'apt signifiers'.

Kress (1997) argues that the notion of 'interest' 'factors in' the social environment in which the sign is made and the social character of the signifier. Nonetheless, I argue that there is a need to look beyond the social as it is articulated through the individual sign maker in order to understand the relationship between the social organisation of people and the production of signs.

Every sign, as we know, is a construct between socially organised persons in the process of their interaction. Therefore *the forms of signs are conditioned above all by the social organization of the participants involved and also by the immediate conditions of their interaction*. When these forms change, so does sign.
(Volosinov, 1973: 21, italics in the original)

To do this I combine a multimodal approach and activity theory to introduce the histories of school subjects, curriculum and assessment that underpin learning in the classroom more clearly into the analysis: the social histories that lie behind instances of learning that a multimodal approach does not easily invoke.

Activity theory is developed from the work of Vygotsky's cultural historical approach of semiotic mediation to learning - in which a subject's relationship to an object is mediated by semiotic tools. Activity theory moves the analysis of technology-mediated learning beyond the idea of an individual learner engaged with what is represented on screen to suggest a more complex view of learning. This complexity can be understood as the mediational effect of tools on a person's activity. People's consciousness is seen as emerging from their activity with shared tools - through which they are always in contact with (connected to) the history, values, and social relations of society embedded in tools (Cole 1996). In common with activity theory, social semiotics understands mediational tools (semiotic resources) as shaping thinking, tools that different groups use to realise their specific interests. Activity theory theorises the rules, norms, and social roles of people within communities that underpin this mediation more clearly than social semiotics.

Engeström (1987) developed Vygotsky's mediational triangle (subject, mediational tool, and object) into an activity system to represent more fully the essential social relations that account for learning. The concept of an activity system is represented in the diagram in Figure 2.1. An activity system can be understood as any group of

people who share a common object and purpose over time, the tools they share to act on an object and realise that purpose (Russell, 2002).

The activity system is a flexible unit of analysis (theoretical lens), which allows us to train our gaze in different directions and with different levels of 'magnification' to help us answer the questions that puzzle us.
(Russell, 2002: 67)

As shown in figure 2.1 activity systems have a subject engaged in activity.

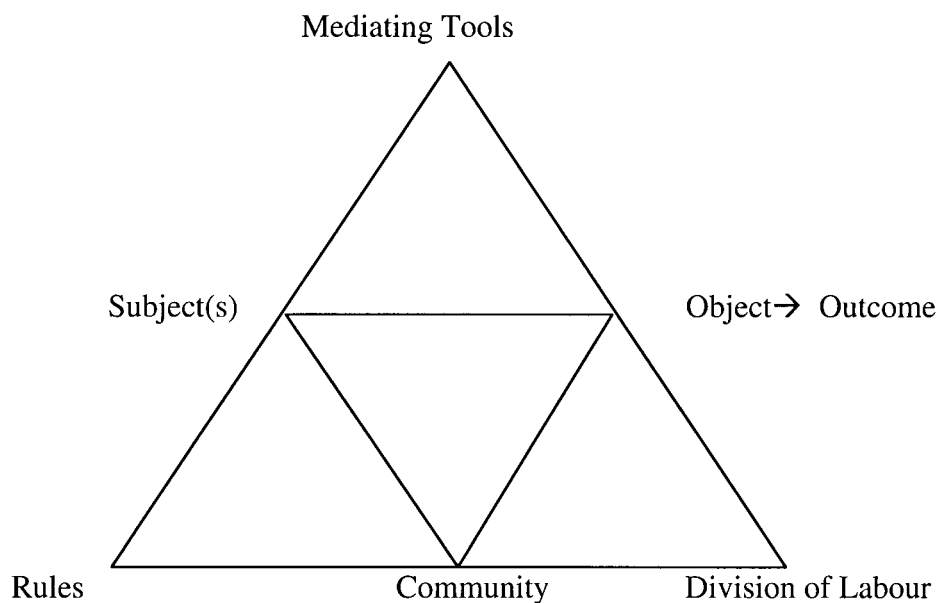


Figure 2.1 An activity system (Engeström, 1987)

In this thesis the subjects are school students and teachers, each of who is located differently within the classroom. The object refers to the material for study or the problem space that the students are working with and which they bring the tools to bear on. In the example of computer mediated learning analysed in Chapter Four, for example, the object is the construction of 'character' in the school English classroom. The students (subjects) use the tools (the modal resources of the CD-ROM) to act on

the object to produce an outcome. The outcome (goal) of the students working to construct 'character', for example, is the production of their GCSE English coursework.

Tool is used to refer to anything that mediates the subject's action upon objects, and these tools can be either physical technical tools or mental conceptual tools (Vygotsky, 1986). The computer like all other technologies/tools that have been introduced into people's activities (the pen, the typewriter, the printing press, etc.) have the ability to transform and reorganise how people deal with intellectual and practical problems and act as aids to thinking. For instance, learning multiplication and calculation with a pen and paper is different than learning these on a computer, and without either it is a different thing again (Saljo, 1999). The calculator incorporates sophisticated knowledge about math operations such as multiplication and division, notational systems including the use of zero and decimals, and how to perform certain frequently used functions, like percentages and square root. When pupils press the buttons on a calculator they are literally operating with conceptual tools that have been developed over thousands of years. The physical and mental conceptual tools incorporated into new technologies prompt the question of how changing the tools (semiotic resources) available to learners or the ways that these tools (resources) are shared and used can re-mediate their interactions. The sociocultural concept of tools is compatible with a social semiotic view of the semiotic resources of modes, their materiality, and affordance. The concept of activity system is useful to consider the framework of relations that semiotic mediation is embedded within/creates in relation to learning.

The bottom elements in the diagram of activity system (Figure 2.1) place the individual subject (in this case the student, teacher or designer) in a wider community and map the essential elements of the social relations necessary to activity. In the examples discussed in this thesis the students (subjects) are part of a class, members of a school and social communities. Within the activity system there is a division of

labour that shapes the ways that subjects (students) act on the object. A teacher and student have specific roles in the classroom. The introduction of a new tool into the classroom can re-mediate these roles and the division of labour between subjects.

Activity systems include explicit and tacit rules, norms, values, and routines. These shape the interactions of subject and tools with the object. Students' interaction with the Steinbeck CD-ROM (discussed in Chapter Four), for example, is informed by the explicit rules included rules of behaviour displayed in the school, the timetable and lesson length, and the values of the English national curriculum as mediated by the teacher, and the teacher's expectation of them.

I use activity system to highlight the elements beyond the immediate observable interaction to be considered in the analysis of the data. Such as the interplay between the computer, the computer application and the different semiotic resources that these make available, the students' purposes, the teacher's purposes in the lesson, the curriculum, and the traditions and histories of school subjects.

Signs and Transformation

For Halliday (1978, 1985) the system of meaning potentials and the grammar of a mode permits an infinite combination of elements within it: the resources of the system, the signifying stuff, remain constant and people's use of these resources, their choice and combination of elements in contexts of use bring about new signifieds, new signs. Following Kress (1997) I see each use of a signifier as realising a new sign and this new sign as changing the potential of the signifier to mean. Slowly over time the signifier changes. Signifiers are constantly worked and remade in the process of making meaning. The motivated sign means that people bring together and connect the available form that is most apt to express the meaning they want to express at a given moment. In this the signifier that they use takes on a new meaning (in the sign) it is transformed by its use. In other words signs are always newly made, always

transformative. These transformations may be in 'entirely minute and barely noticeable ways' (Kress, 1997: 94).

The concept of the motivated sign and signs as always newly made may seem to contradict the earlier discussion of the regularities or grammars of modes. If signs are motivated by the situated interests of people then how do modes have recognisable regularities in the relation of meaning and form? In response to this question one point to make is that both the regularities of modes and the interests of people are socially shaped to realise conventions. Another point to make is that people work with the semiotic resources (signifiers) that are available to them in the social contexts that they live in. These resources are historically made and this history shapes the kinds of things that they can be used to mean – what can be done with them. The regularity of a modal resource can be understood as the result of its immersion in cultural systems (and the immersion of sign makers in cultural systems).

The patterned regularities of modal resources are not however God given and unchanging, they are socially made (and un-made). Like the paths cut into the landscape of parks and green spaces through people's everyday journeys there is both regularity of resources, fluidity and change. The paths made by people may eventually be covered in tarmac or paved over, and these may provide a model for the future design of paths (become 'convention'). Some paths will become redundant as the environment around them changes. There will be new places to get to and new paths will emerge. The motivated character of signs made by young children, who to continue the analogy may not yet recognise the path or the social convention of sticking to it, is often easier to 'see'. Young children have not been fully inducted in to the social conventions of meaning making, and have limited knowledge of or access to some semiotic resources for make sign making. As a result their sign making often stands outside of convention (to the extent that often only the child's immediate family can understand their signs). The concept of sign as motivated and

transformative highlights the continuous social ‘work’ involved in producing and maintaining the conventions of meaning. In other words the grammars and conventions of modal resources are upheld by people’s constant making of signs, not by the arbitrary relationship of form and meaning.

The motivated transformative sign highlights the importance of the kinds of semiotic resources that are available to the sign maker to choose from. The semiotic resources that are available for sign making are intimately connected with the social location of the sign maker, as well as her of his social context. In the process of sign making the semiotic potentials of a mode are constantly changed both at the level of ‘grammar’ and the elements for meaning making. New resources come into the potentials for meaning making and new arrangements of these elements are introduced. This is important within multimodal theory as it opens up new possibilities for semiotic resources to come into the stock of meaning making potentials. The concept of sign and sign making that I use in this thesis is therefore more fluid than in the work of Halliday and other systemic functional linguists.

External Signs, Mind and Learning

As already discussed, modes make available different representational and communicational affordances and as a consequence modes mediate learning in different ways. This is significant for learning because the semiotic resources in the social worlds that people live in are fundamentally connected to the development of mind and ways of thinking. The notion of sign making presented in the previous section of the chapter, which focuses primarily on ‘external material signs’, can be integrated with a sociocultural notion of internal sign making. Sociocultural theory assumes that any function in a person’s cultural development appears first between people in their social interactions (the social plane), and second ‘within’ the person (the internal plane) (Vygotsky, 1981). This process is termed internalisation and can be described as a process of the internal taking in and reworking of the social plane. As I discussed earlier in relation to external signs, internalisation is mediated by

semiotic mechanisms (modes and modal resources) which, "...provide the bridge that connects the external with the internal and the social with the individual" (Wertsch, 1985:164). Consciousness or mind can be understood as taking shape in the semiotically mediated social interactions people are engaged with in the material world. The mind is 'nurtured on signs' deriving 'its growth from them' (Volosinov, 1973: 13). Signs that are made available on the social plane are 'taken in' by individuals and as they pass through the 'psyche' they are transformed:

...every outer ideological sign, of whatever kind, is engulfed in and washed over by inner signs - by the consciousness. The outer sign originates from this sea of inner signs and continues to abide there.
(Volosinov, 1973: 33)

It is this continual process of making sense and building sense that forms an individual's consciousness/cognitive development (Wegerif and Mercer, 1997). From this perspective learning is not the acquisition and accumulation of given semiotic meanings, but rather it is a process whereby meanings are taken in by a person, and made sense of in the context of their present and previous experience, and re-made by them. I argue that the fundamental connection between external and inner signs highlights the importance of exploring how the semiotic resources of *all* modes, not only speech and writing, contribute to learning.

In this thesis I do not set out to answer the complex question of exactly how different communicational modes are processed 'in the mind'. It is generally agreed that different forms of external representation affect human cognition differently (Jehng et. al, 2000). For instance, people have been shown to recognise, retain and recall images better than words, and the simultaneous presentation of interrelated visual, written, dynamic graphics, and sound has been shown to increase their comprehension – one measure of learning (Tricot et al, 2000). It is fair to say that how people mentally process different modes of information remains a matter of debate (Dubois and Vial, 2000). Some research claims that one representation of

knowledge exists in memory in a purely propositional form in which the communicational modes are transformed in some unifying way. Other research suggests that there are distinct information-processing systems for image and word, and other modes.

I want to argue that the multimodal character of the social plane suggests that it is possible that the formation of consciousness and what goes on in 'the mind' is itself multimodal or at some level beyond mode. (If it is beyond mode it is not through speech either.) I want to suggest that signs may not be internalised and 'transformed' into inner speech and may 'exist' as a fragmentary fuzzy multimodal meaning.

Multimodal Learning

Viewing signs as motivated and transformative as outlined in the previous section has important implications for thinking about learning. First, students' signs are never (more or less competent) repetitions, reproductions, copies, of the teacher's sign: the students' signs are always transformations of the resources that were available to them, made in the light of their interest at the point of making the sign. The selection of a signifier can not be treated as an error or a mistake as the student's sign is not a copy of the sign of the teacher but an expression of her or his interest. Second, this concept of sign shifts the focus from sign system to sign making. In doing so it challenges the notion of sign making as a matter of the sign maker's competence to suggest that sign making is a matter of the design of meaning. The sign as arbitrary means that learning is essentially about acquiring an abstract system of resources that is outside of the learner. The role of the student is to learn the rules and codes of the system. If the student fails to do this they are considered to have an inability to cope with the abstract system, and the meanings that they make, and indeed they themselves are read as failures. Understanding sign making as motivated focuses instead on the sign maker's design of meaning with the resources available to them in a specific context.

From a multimodal perspective a range of modes are seen as contributing to meaning making (including gaze, gesture, movement, body posture, spatial location, image, speech, music, sound-effect, and so on). It follows then that all modes have the potential to contribute to learning. In other words, learning is not thought of as a primarily linguistic accomplishment and the range of modes need to be included in the analysis of learning. In relation to technology-mediated learning I show in this thesis that it is not adequate to focus only on talk around the computer and that the multimodal resources as they appear on the computer screen and students' multimodal interaction with these both need to be analysed.

The theorisation that each mode has different material and social affordances has implications for learning. These modal affordances represent or shape curriculum knowledge differently. Each mode has different potentials for expression making the choice of mode a crucial part of the production and the shaping of knowledge. The functional specialisation of a mode over time means each mode has different potentials for representation and communication of knowledge. This is important for learning as school curricular subjects draw on the semiotic resources of modes in different ways. Within the classroom the work of the teacher often draws on semiotic resources of a range of modes (gesture, gaze, manipulation of models, speech, image, etc.). In contrast, the work of students, in particular work for assessment is often restricted to the mode of writing. Learning therefore involves students in the work of translating information across modes, or 'transduction' (Kress, 1997).

Modes are used in specific communicational events to carry different kinds of information or messages. This suggests that an analysis of learning that focuses on speech and writing, or any one single mode may fail to capture the work that students are engaged in and the meanings that they make. Focusing only on the writing in a student's text or the screen of a computer application for instance will not be able to account for the complex ways in which the meanings of images in the student's text or on the screen interplay with the writing. This highlights the need to explore how

modes interact in a learning situation. The need to look beyond language to how modes interact is highlighted by the silent activity that accompanies much technology-mediated learning. To continue to connect learning with talk at the exclusion of all other modes is, as I demonstrate in this thesis, a restrictive concept of learning.

The facilities of the medium of computers impact on learning. The semiotic resources of interactivity and the linking web structures of computer applications, for instance, provide the potential for new practices of reading, producing and disseminating texts. The range of modes made easily available via computer applications and the configuration of these resources on screen offer students a wider range of semiotic resources for learning than do some other medium.

Texts and Practices as One Evidence of Learning

Sociocultural and multimodal theories of the fundamental connection between external signs and cognitive development and learning enables students texts (complex signs) to be analyzed as one kind of evidence of their learning and the cognitive processes they engaged in. The patterned exchanges and interactions that enact texts are always immanent in them, they are always materially embodied in and through them. In short texts occur in "...some relation of homology to the dynamic social semiotic processes that enact them" (Thibault, 91 p.11). Students' multimodal engagement with the screen and the texts that they produce can therefore be analyzed as material traces of the choices that they made from the resources that were available to them. In short consciousness and learning are understood and interpreted as a sign: the 'consciousness externalised' (Volosinov, 1973:33).

Outside objectification, outside embodiment in some particular material (the material of gesture, inner word, outcry) consciousness is a fiction...But consciousness as organised, material expression (in the ideological material of a word, a sign, drawing, colours, musical sound, etc.)is an objective fact and a tremendous social force.
(Volosinov, 1973: 90-91)

I interpret student's material expressions, signs, images, writing, gestures, and so on as one trace of the expression of students' engagement with knowledge in the classroom: one kind of evidence of what their thinking and learning may have been like.

Summary

In this thesis I use a multimodal approach to technology-mediated learning drawing on social semiotic theory and activity theory. I show that each mode offers different communicational and representational resources and that understanding learning requires all modes of communication, not only speech and writing to be brought into the analytical frame. The concepts used in the thesis include, mode, semiotic resource, materiality, modal affordance, functional specialisation, functional load of modes, the interaction of modes, semiotic mediation and activity system. (Each of these concepts has been described above, how they are operationalised analytically is discussed in the next chapter.) From this perspective modes provide people with a range of semiotic resources or meaning potentials with different representational and communicational affordances. These modal resources shape meaning and knowledge in distinct ways.

I treat sign making as an active process in which people bring together form (signifiers) and meanings (signified), in which they select the most apt signifier for the meaning that they wish to signify at a given moment and context. I theorise sign making as a multimodal motivated and transformative process. I understand this motivation as the result of the complex interaction of the sign maker's 'interest' (at a specific moment in a specific context), the rules and norms of the school and the school classroom, the curriculum and the histories of subject knowledge, and the roles of teacher and students.

This approach to sign making is significant for thinking about learning as a multimodal process. Students are understood to be actively making signs selecting,

using, and adapting the multimodal semiotic resources available to them in order to realise the most apt and plausible signifier to express the meaning that they want to express. Viewing signs as motivated and always transformative leads signs to be understood as a trace of the designed interests of the situated sign maker. This challenges the view of learning as acquiring competence, and suggests that learning is a process of multimodal design. The theorisation of the fundamental connection between external signs and cognitive development and learning enables students texts (complex signs) to be analysed as one kind of evidence of their learning and the cognitive processes they engaged in.



In the next chapter, Chapter Three, I discuss how the theoretical concepts introduced in this chapter are operationalised in the thesis.

3. Towards a Multimodal Analysis

Introduction

In this chapter I describe how the theoretical concepts introduced in the previous chapter are operationalised in the analysis of instances of technology-mediated learning in the thesis. I discuss how I combine a range of approaches to explore the role of different modes in order to look beyond language: first, focusing on the modes individually, then the semiotic resources that each mode makes available to the students in the classroom, and finally examining the interaction of modes. I then go on to describe the semiotic resources that each of the modes I analyse in the thesis makes available and how these resources realise the ‘meta-functions’ discussed in Chapter Two. For the purpose of this thesis the term ‘mode’ is used to refer to an organised set of semiotic resources that realise the ‘meta-functions’ to some degree. The modes that I discuss in the chapter and throughout the thesis more generally include image, colour, speech, and sound-effect, movement and gesture, and gaze. The way in which the interaction of these modes contributes to meaning making and the dimensions that I use to explore this interaction is also discussed. The facilities of the medium of the computer contribute to the character of technology-mediated learning. For this reason I discuss how I engage with these facilities within the thesis, including the range of modes available, the potential for interactivity, the role of structure and hyperlinks in making meaning, and the screen as a site of display as compared with the page. Drawing on the theoretical discussion of ‘sign’ and ‘learning’ in the previous chapter I discuss how I operationalise the concept of the motivated sign within the thesis. The chapter concludes with an overview of the data, the processes of data collection, and the methodological issues of sampling and transcription.

Theoretical Concepts and Analytical Procedures

In order to explore how the multimodal resources of computer applications contribute to technology mediated learning I *look beyond language* and attend to all modes. Any system consisting of elements that can be brought into sign making and principles for their organisation in relation the ‘meta-functions’ is treated as a ‘mode’. Working with the concepts of mode, materiality, modal affordance and logic, semiotic resource and the meta-functions three approaches or starting points for the analysis of multimodal meaning making have emerged in multimodal analysis.

The first approach foregrounds the concept of mode. The semiotic resources for meaning making offered by each mode are analysed. The decision to focus on individual modes in this way is a pragmatic one. While modes always work together to realise meaning the complexity of multimodal texts can make it difficult to know how to start to ‘get at’ its meaning. Focusing on the semiotic resources of individual modes is a useful analytical tool to prise open a text. It is clear however that analysing modes individually realises only a part of the potential meaning of a communicational event or text: the interaction between modes offers another ‘layer’. In other words the interaction of modes, their juxtaposition, and relations realises meaning. The second approach foregrounds the concept of the meta-functions. The concept of meta-functions offers an analytical tool to analyse how the modes work together to realise different kinds of meanings. How the semiotic resources of image, sound-effect and animated movement, for example, might all work to construct ideational or interpersonal meaning in the classroom, or how the coherence of a text or communicative event is realised through the combination of the resources of these modes. All of the modes that I discuss in this thesis realise the ‘meta-functions’ although the modal resources of some modes are more specialised with regard to the ‘meta-functions’ than some others.

The starting point for the third approach to multimodal analysis is the semiotic principles that work across modes. Multimodal principles are common threads that

weave across texts, and these offer an analytical tool to explore multimodal meaning of a text. Here the focus is not on modes, or meta-functions but on larger scale principles such as design, production, frame etc (Kress and van Leeuwen, 2001).

I use these three approaches to multimodality in combination as each offers a different scale and perspective for the analysis of meaning. Moving from the semiotic resource and individual modes, to semiotic principles at the level of text opens up different ways to think about meaning.

I bring together the multimodal resources of the two levels of screen, and of classroom interaction to explore the semiotic resources made available for meaning making in technology mediated learning. The range of modes made available by computer applications and their use is analysed in the thesis including image, colour, sound-effect, voice, movement and gesture, and gaze. I also analyse students' use of modes in their multimodal interaction with the computer and one another. This includes movement, gesture, and gaze with the computer (the screen, mouse, keys, etc.), and talk.

The concept of 'modal affordance' and 'logic' contribute to understanding the specific functions of modes in a computer text and student interaction with these. I use these concepts to explore when and how modes are used to mean in instances of technology mediated learning. These concepts also suggest that the transduction of information across modes is one key to learning. The concept of 'materiality' is applied to examine how the texture and material provenance of elements as they appear on screen enter into meaning. For instance, in Chapter Five, I discuss how the materiality of Toontalk tools changes when the user selects a tool. I show that the different material realisation of the tools, from the materiality of hard plastic blocks to soft pliable organic forms when they are selected, signifies their changed 'usability' of the tools and the control of the user.

I operationalise the concept of meta-function as an analytical tool for analysing the meaning potentials of modes. I use the ideational meta-function to focus the analysis of how the semiotic resources of computer applications present ‘the world’ – what is included and excluded and how the resources shape knowledge (e.g. the entity ‘character’ or ‘rule’). The interpersonal meta-function is used to explore how these resources position the learner in relation to knowledge. I use the textual meta-function to examine how the configuration of semiotic resources on screen organises these into texts.

As I discussed in Chapter Two, modes have been developed to different degrees through their social usage, some such as writing and visual communication are finely articulated. Other modes, such as colour, sound-effect and voice are less fully articulated. Despite the different degree to which modes are specialised around the meta-functions the mapping of semiotic resources provides a useful way to analyse multimodal meaning making. The semiotic resources of visual communication, gesture and movement are for example more clearly ‘structured’ in relation to the meta-functions than the modes of colour, sound-effect, voice quality and gaze. Alongside the metafunctions I turn to the concept of the ‘materiality’ of semiotic resources as an analytical tool.

In all modes the meta-functions stand behind the concept of ‘semiotic resource’. The concept of meta-functions and semiotic resource offer a useful way to look at how different modal resources can be collected into sets of options or system networks to realise key aspects of meaning functions. System networks can be used to map the semiotic resources or meaning potentials of image (Kress and van Leeuwen, 1996), action (Martinec, 2000), sound-effect and voice (van Leeuwen, 1999) and gaze to specific meaning functions and are used as an analytical tool in this thesis. Rather than understanding system networks as a blueprint of meaning making, however, I understand them as analytical tools analogous with a rough map of the semiotic possibilities available, a sketch or backdrop to meaning making. It is important to

emphasise that the way in which people apply the semiotic resources outlined in the next section is not set in stone: people application of semiotic resources in specific instances differ in different cultural contexts and people may choose to break social conventions.

The Semiotic Resources of the Mode of Image

The semiotic resources of visual communication are finely articulated and are specialised along meta-functional lines in the multimodal environment of the screen (and elsewhere).

Ideational Meaning

The semiotic resources of image like speech and writing enable people to construct visual representations of what goes on in the world: realise their experience of the world (external and internal). Ideational meaning can be realised through visual (syntactic) patterns in terms of their function of relating visual participants to each other in meaningful ways. There are two kinds of pattern. Narrative representations relate participants in terms of doings and happenings, of the unfolding of actions, events, or processes of change. Conceptual patterns represent participants in terms of their more generalised, stable or timeless essences. Conceptual representations represent the elements depicted in an image as being something, belonging to some category, or having certain characteristics or components. The choice of a narrative or conceptual form of representation is important, since the decision to represent something in a narrative or conceptual way provides a key to understanding the discourses that mediate their representation.

In visual representations, narrative structures are recognised by the presence of a vector. A vector is a line, usually diagonal, that connects participants. The vector expresses a dynamic, doing or a happening kind of relation. These processes can be either agentive (involving an actor) or non-agentive. 'Actors' are the participants from

whom or which the vector emanates, or who themselves form the vector. 'Goals' are the participants at whom the vector is directed. When a picture or a scene within a picture has both an actor and a goal it is transactive, representing an action that is taking place between two parties. It is also possible to have a picture or scene with only an actor and a vector. For instance, the eye-line and the direction of the gaze of represented participants realise a special kind of vector. It can also realise a reaction rather than an action. Such a reaction can, again, be transactive or non-transactive. It can be that both the person (or perhaps animal) who is depicted as looking and the object of his or her gaze (transactive reaction) are shown, or only the person looking and not what he or she is looking at (non-transactive). The concepts of narrative visual analysis (action, reaction, transactive, non-transactive) can be used to analyse a visual text - to address questions such as who is shown active, and who is shown as reactive in visual texts in relation to a particular issue. Alongside the realisation of these processes narrative structures include what Kress and van Leeuwen (1996:) call 'circumstances'. Circumstance is used to refer to the setting, means and accompaniment of these processes.

Images that do not contain vectors are termed 'conceptual structures'. They visually define, analyse or classify people, places and things. One kind of conceptual pattern is that of classification. This brings representations of entities, people, places or things, together in one picture, distributing them symmetrically across the picture space to show that they are equivalent in some respect, that they have something in common, and that they belong to the same 'group'. 'Symbolic attributive' structures define the meaning or identity of a participant. For example, in Chapter Six, I discuss the use of the props of scientific equipment in the CD-ROM *Multimedia School Science* to confer the symbolic meaning of investigation.

Interpersonal Meaning

Images create particular relations between viewers and the world inside the picture frame. In this way they interact with viewers and suggest the attitude viewers should

take towards what is being represented. Three semiotic resources have a role in the realisation of these meanings: distance, contact and attitude. Together these can realise complex and subtle relations between the elements represented and the viewer.

Through the semiotic resource of 'distance' images can bring representations of people, places and things close to the viewer or make them distant. In everyday interaction cultural norms of social relationships influence the distance that people keep from each other. To see people close up, every detail of their face, is to see them in a way that is usually reserved for people that are intimate with one another. To see people at a distance is to see them from the position that people would normally see strangers. The physical distance that one person has from another person has social meaning and this meaning can be realised in the visual representation of distance. Different distances signify different degrees of formality and intimacy. I draw on the semiotic resource of social distance to analyse the interpersonal meaning signified in the computer applications discussed in this thesis, that is how distance is used to project a particular social relation between the producer, viewer, and the entities represented on screen.

Attitude (visual angle) is another visual semiotic resource that contributes to the positioning of the viewer. The horizontal and vertical angle that an element is represented from encodes the position of the viewer. In the case of the horizontal plane, the relation will be one of involvement with, or detachment from, what is represented. A frontal angle produces maximum involvement. The viewer is directly confronted with what is represented in the picture. If something is depicted from the side (from an oblique angle), the viewer is literally and figuratively on the side (lines). There are many degrees of involved or detached engagement in between. The vertical angle also contributes to the elements and events displayed, one of 'semiotic' power. If the viewer looks down on something, she or he looks at it from a position of power. If they look up at something, that something has some kind of power over them. At eye-level there is a relation of equality.

Point of view is also produced by the kind of 'contact' established between the viewer and the represented people or objects (with human characteristics such as eyes). Many pictures show people who look directly at the viewer. In this way they make contact with the viewers, establish an (imaginary) relation with them. Kress and Van Leeuwen (1996) call these 'demand images', in which the people in the picture symbolically demand something from the viewer. Without this kind of imaginary contact the viewer looks quite differently at the people inside the picture frame. They observe them, in a detached way, and impersonally, as though they are specimens in a display case. Kress and van Leeuwen call such pictures 'offers', that is an offer of information is made.

Kress and van Leeuwen (1996) classify the realism of images, or 'coding orientations' in three ways, as naturalistic, scientific, or sensory (or a combination of features of these). A naturalistic coding orientation presents that which is represented as 'how it (actually) is; how you can see it in the world' resting on the most commonly available, naturalising technology of photography. If an image displays more sharpness, more colour saturation, or a deeper perspective than the average colour photo it begins to look 'more than real' what Kress and van Leeuwen call sensory coding orientation and Goffman calls 'hyper-real' (Goffman, 1979). Scientific coding orientation on the other hand is based not on what things look like in a specific situation, and from a specific angle but on how things are in general or according to some deeper, 'hidden' truth. The scientific image probes beyond the surface and abstracts from detail. There often is no background, detail is simplified or left out, and colour and depth may be regarded as superfluous. These are means of expression that ensure that reality from the point of view of naturalism is here regarded as unreal and irrelevant. Throughout chapters Four, Five and Six I explore the representation of realism on screen.

Textual Meaning: Visual Design

Information values are realised by the placement of the elements of a composition. The role of any particular element in the whole depends on whether it is placed on the left or on the right, in the centre or the margin, or in the upper or the lower part of the picture space, page, or screen. Throughout the chapters in Part II of the thesis I examine these information values in relation to the visual design of the screen space in the computer applications.

In societies which use Roman script the direction of the reading of a text (left to right, from top to bottom) has led to different cultural values being awarded to the left and the right. According to Kress and Van Leeuwen left-right placement creates a given-new structure. The elements placed on the left are presented as ‘given’, the elements placed on the right as ‘new’. For something to be given means that it is presented as something the viewer or reader already knows, as a familiar and agreed departure point for the message. For something to be new means that it is presented as something not yet known to, and not yet already agreed upon by the viewer or reader, hence as something to which the viewer or reader must pay special attention. The new is therefore problematic, contestable, the information at issue, while the given is presented as commonsensical and self-evident. Again, this is a meaning potential which becomes precise in the working of a specific sign and will get more specific contours in the context of specific images.

The ‘bottom’ and the ‘top’ of the visual space also present a meaning potential. If some a constituent element is placed on top and another at the bottom of a visual space, then what is placed on top is presented as what Kress and Van Leeuwen call the ‘ideal’, and what is placed at the bottom as the ‘real’. For something to be ideal means that it is presented as the idealised or generalised essence of the information, hence usually also as its ideologically most salient part. The real is then opposed to this in that it is its meaning potential to present more down to earth information.

‘Centrality’ is a signifier potential of ‘that which is central’. Depending on the overall visual design of a visual space the element that is placed in the centre can mediate the other elements in the composition. The marginal elements are then in some sense the elements that belong to or are subservient to the central elements, depending on the context.

The term ‘framing’ is used to indicate that elements of a composition can either be given separate existence, or represented as belonging together. In other words, framing connects or disconnects elements. Disconnection can be created in many ways, through frame-lines, through empty space between elements, but also through contrasts of colour or form, or any other visual feature, in short through any form of discontinuity, disconnection or contrast that can be visually signified. Connection can be achieved in exactly the opposite way, through similarities and rhymes of colour and form, through vectors that connect elements, and of course through the absence of frame-lines or empty space between elements. In every case the discontinuity or continuity between elements expresses what it is that the elements are separated by or made to belong together. This broad meaning potential can then be made more precise through the context, and also through the means of framing chosen. In this thesis I show that when applied to the computer screen the concept of compositional meaning or visual design can be realised through the composition of the elements on screen, hyperlinks and editing.

The term ‘salience’ is used by Kress and Van Leeuwen to indicate that some elements are given semiotic prominence or made to ‘stand out’. Salience can be realised in a range of ways, through size, through colour contrasts (red is always a very salient colour), tonal contrast, in short through anything that can make a given element stand out from its surroundings.

The Semiotic Resources of the Mode of Colour

The semiotic resources of colour are developed for sign making and have principles of organisation. In this thesis, I therefore treat colour as a mode. Colour combines with other modes but does not exist as a mode on its own but rather it relies on a multimodal environment for its existence (Kress and van Leeuwen, 2002:351). Like other modes it is meta-functional; it can denote ideational, interpersonal and textual meaning. However the resources of colour are not (yet) specialised in the way that some other modes, speech, for instance, are. The materiality of colour also offers a way into the analysis of its semiotic resources. The resources of colour as mode, as described by Kress and van Leeuwen (1996, 2002) that inform my analysis of the computer applications presented in this thesis are outlined below.

The semiotic resources of colour include the 'grey scale', the scale from white (maximum light) to black (maximum dark). The extremes of this continuum, light and dark have come to have meaning and value in many cultures in different ways. Colour can also be intense or saturated or soft and pastel, this continuum of 'saturation' realises emotion according to Kress and van Leeuwen (2002). They argue that high saturation can be a signifier for an emotional expression of energy and emotion and low saturation a restraint of lack of energy or emotion. 'Modulation' is another resource of colour, the scale that runs from richly textured tints and shades to flat colour. The modulation of colours is associated with particular values and coding orientations. For instance flat colour is associated with the 'essential quality' of an object and 'abstract truth', whilst textured colour is associated with 'specificity' and 'naturalistic, perceptual truth' (Kress and van Leeuwen, 2002: 357). Colour 'differentiation' is a semiotic resource that runs from monochrome to the use of a diverse range of colours. High colour differentiation has come to mean 'adventurousness' and low colour differentiation as meaning 'timidity' in the context of home décor (Kress and van Leeuwen, 2002:357). Finally, 'hue', that is what colour is used, is a semiotic resource associated with a signifier potential continuum from cold (blue) and warmth (red).

The Semiotic Resources of Sound

Like colour the resources of sound are less clearly specialised along meta-functional lines than language and visual communication, however the modes of voice, sound-effect and music do realise the three meta-functions and is treated as a mode. In western cultures, however, sound cannot be treated in the same way as language and visual communication as it has not reached the '...levels of abstraction and functional saturation that (written) language and image have reached...' (van Leeuwen, 1999: 192). Theoretically the meta-functions apply in the same way but to a less fully articulated mode; and therefore the range of meaning potential is less constrained. Van Leeuwen uses the material aspects of sound rather than its communicative functions as an entry point to identify the semiotic resources of sound. The modes of voice and sound effect are two modes that feature in the analysis that I offer in this thesis. The main semiotic resources that I draw on from van Leeuwen's work are briefly outlined below.

The semiotic resource of 'social distance' described in some detail earlier in relation to visual semiotics can be used to think about sound. The social distance between the listener and (the maker of) a sound is realised by its volume, aural nearness and sound quality. The semiotic quality of an intimate whisper, a far off shout or a public announcement each signifies a different kind of social relation between the maker of the sound and its receiver. Sounds also mark interaction through the use of what van Leeuwen calls 'sonic interaction' (van Leeuwen, 1999). This means that sound can be either monologic or dialogic (between individuals, groups, etc.).

Sound time is a semiotic resource that organises aural texts. A sound can be either a fluctuating or continuous unmeasured sound or a rhythmic measured regular sound (with many variations of what this can mean). Another semiotic resource of sound used in this thesis is 'sound quality', that is whether a sound is tense or lax, loud or soft, rough or smooth, and so on.

The Semiotic Resources of the Modes of Movement and Gesture

As discussed in Chapter One, when people use computers they point, click, hold the mouse, lean forwards and back and move through screens often without a spoken word. This highlights the importance of a multimodal approach to analysing technology mediated learning and the role of action within this multimodal ensemble. The semiotics of movement and gesture (used to refer specifically to hand movements) are not as close to awareness of as explicit as the mode of image for many people. For some communities however the semiotic resources of gesture are fully articulated modes. The sign languages of the hearing impaired and to lesser extent sign-systems such as semaphore are two examples of articulated gestural modes within specific communities. Outside of these specific communities, movement and gesture offer semiotic resources that are constantly brought into sign making and possess regularities that are 'grammatical' enough so that they can be contravened and are organised along the lines of meta-functions.

Movement and gesture realise ideational meanings about the world, different kinds of engagement and interests, interpersonal meaning, and textual meaning. The main dimensions that I use to analyse the interaction of students with the computer and with one another via the modes of action (movement) and gesture, and the movement of elements on the computer screen are discussed below. My use of these dimensions in this thesis is developed from the semiotics of action developed by Martinec (2000). Martinec draws on systemic functional grammar and social semiotics to classify movements in action into different kinds of patterns on the basis of their observable realisations. These dimensions also draw on research into movement and gesture undertaken by the author and others in the Science classroom (Franks and Jewitt, 2001; Jewitt et. al, 2001; Jewitt and Kress, 2002b) and the English classroom (SEP, 2002).

Ideational Meaning

Movement and gesture can be classified into different kinds of ‘narrative processes’ in a similar way to visual communication. The ‘processes in action’ can be described as either ‘doing’ which is realised by some kind of movement, or ‘state’ which is realised by a lack of movement a stillness (Martinec, 2000: 314). When an action is realised it can either be directed at another person or object (e.g. the screen or mouse) or non-directed (without a goal). As in the mode of image, the question of who or what is acting and who or what they are acting on is central to the semiotic analysis of movement and gesture or classroom interaction more broadly speaking.

Alongside the analysis of the processes of action (movement and gesture) is what Martinec calls ‘aspects of the processes’ which he defines as speed and force (Martinec, 2000: 315). Drawing on the materiality of movement and gesture, I expand the notion of ‘aspect’ in this thesis to include the dimensions of ‘openness’ versus ‘closeness’, ‘roughness’ versus ‘smoothness’, ‘tense’ versus ‘lax’, and ‘direction’. At a first and most general level these dimensions have associated semiotic values. The speed of a gesture can be fast or slow and the degree of deliberation expressed, can either be done to signify the competence (habituated action) or the confidence of the person making it or their indifference. If a movement or gesture is rough and jerky it may signify a lack of control or the difficulty of a task. In contrast a smooth gesture may be used to signify control and ease. In addition to narrative processes, like images, movement and gesture can realise conceptual meanings. Movements and gestures can be ‘symbolic’, for example the wave of the Toontalk robots as a gestural appeal to the user for action (see Chapter Five).

Interpersonal Meaning

The variation of ‘distance’ and body angle between people (and/or the objects that they interact with) realise different kinds of interpersonal relations or what Martinec calls ‘degrees of engagement’ (Martinec, 2000: 317). The semiotic resources of social distance and ‘attitude’ (angle) described earlier in relation to visual and aural

communication can be applied to movement and gesture. As a person moves nearer or farther away to another person or object the social distance between them is decreased or increased and this realises different kinds of relations between them. Similarly if a person angles their body in a direct frontal angle towards another person or object their engagement will be stronger than if they stand next to or at an oblique angle to them.

Textual Meaning

Movement and gesture realise textual meanings. An actor, the process of their action, and the location of the action can be related in different ways. Cohesion can be realised through the similarity or contrast of gestures and movements, actors, or location. The cohesion of a communicative event or text can be realised through the rhythmic repetition of gestures and movements or a sequential unfolding relationship as gestures build on and extend one another.

The Semiotic Resources of the Mode of Gaze

Gaze features in the analysis of students' interaction with computers in the classroom. What a person is looking at and how they are looking at it is frequently interpreted as a sign of attention or lack of it, a sign of respect or lack of it and so on (Lomax and Casey, 1998; Heath et al, 2002). The mode gaze realises the meta-functions (Lancaster, 2001; Kendon, 1990).

Through the resources of Gaze elements can be brought into the communicative realm of what is included in the 'world, ideational gaze can either be directed or non-directed. A directed gaze (transactional) can 'act on' objects and other people bringing these into the realm of attention. Objects and people can be selected and given importance through gaze, they can be ignored and made marginal. A gaze can be non-directed that is it has no visual goal.

A person's gaze can realise interpersonal meaning; it can create engagement or a lack of engagement. Gaze, like visual communication and action, makes available the semiotic resource 'attitude'. The horizontal and vertical angle of a person's gaze encodes their position in relation to what it is they are looking at. The horizontal angle of a gaze can indicate involvement with, or detachment from, what is being looked at. A direct frontal gaze allows the creation of maximum involvement that can be read as a kind of demand. The vertical angle also signifies a person's attitude to the events they are looking at. If the person looks down on something, she or he looks at it from a position of symbolic power. If they look up at something, that something has some kind of symbolic power over them. At eye-level there is a relation of symbolic equality. The person may move to realise these different attitudes to an object, a teacher for instance may sit or kneel to achieve eye level contact with a student. A person can also refuse to meet the gaze of another, refuse their visual offer of engagement.

The length of time a person holds a gaze for is another semiotic resource available to people. To take a long look at someone or something in one context may signify power in some contexts and intimacy in another. To take a short look at someone or something may signify lack of power in some contexts and dismissal in another. The stability of a person's gaze is another semiotic resource, for example, a gaze can be steady and certain or fluctuating and hesitant.

In this thesis, the semiotic resources of visual communication, colour, sound-effect, speech and voice, movement and gesture, and gaze outlined above inform the transcription and analysis of the interaction of students with one another and the computer as well as the multimodal resources of the computer applications.

The Interaction of Modes

In addition to mapping the semiotic resources of the modes and looking at how these resources realise meaning (meta-functions) multimodal analysis requires attending to how modes interact in a communicative event. One approach to this, that I mentioned earlier is to examine how the resources of modes work together to realise ideational, interpersonal, and textual meaning, that is three meta-functions. Mapping how the semiotic resources of each mode in a communicative event or text contribute to these specific kinds of meanings is my starting point in the thesis.

The discrete but interconnected concepts of functional specialisation of modes and functional load offer a tool for analysing how these modal resources contribute to meaning of a communicational event or text. I employ the concept ‘functional specialisation’ to theorise the specialised representational and communicational functions of modes at a general level. The concept ‘functional load’ is used to analyse the distribution of information across the modes in the specific instances of learning that I analyse in the thesis. The concept of modes being ‘foregrounded’ or ‘backgrounded’ in a communicative event or text provides a further tool for the analysis of the interaction of modes. Using these concepts I analyse the interaction of modes including the use of different modes to reinforce the ‘same’ message, to carry or elaborate different aspects of the overall message, or to convey contradictory aspects of a message.

The semiotic principles of discourse, design, production, and dissemination that Kress and van Leeuwen (2001) argue stand behind multimodal communication and operate across modes are used as a framework for thinking about meaning making in the multimodal context of computer mediated learning. The concept of design is most useful for the purposes of this thesis. I use the concept of ‘design’ to explore how discourses are formulated in computer applications through the combining of specific semiotic modes in particular ways, to explore the realisation of discourses of the designers of the computer application and the texts made by the students.

Medium and Screen

In order to understand how technology contributes to learning I argue that it is necessary to understand how the medium shapes the semiotic potentials available, and how these potentials are actualised through students' engagement with them. In short, the facilities of the medium need to be drawn into the analysis.

Technology enters fundamentally into the semiotic process: through the kinds of meaning which it facilitates or favours, and through the differential access to the means of productions and reception which it provides.

(Kress and van Leeuwen, 1996: 233)

One way to do this is to understand the relationship between mode and medium as one between technologies of representation (the modes of 'multimodality') and technologies of dissemination (the media of multimediality). Medium refers to how texts are disseminated, such as printed book, CD-ROM, and other kinds of computer application. The facilities of the media are 'parallel' to the affordances of the mode. This raises questions of what it is readily and easily possible to do with a medium. The facilities of the media of computer applications (e.g. CD-ROMs, computer programming applications, hypertext, websites, etc.) have the potential to use a range of communicational and representational modes, to enable easy movement between applications, for interactivity, and hypermodality.

It is important to note that although the facilities (potentials) of a medium contribute in crucial ways to the constraints and possibilities for realising meaning these facilities do not determine it. Meaning is realised by the sign-makers 'design' (arrangement and selection) of the potentials afforded by a medium, and the social context of their use. The use of this potential depends on the purpose, intention, and context of the application. For example, pre-school books use image, writing, movement and sound, they include interactive potential (push here, pull there),

promote high reader authority - the images present visual potentials with which to construct a narrative, and possess a weak linearity. Computer applications have the potential to make a range of modes available on screen, however, a web site may use minimal visuals, possess limited potential for interactivity, and promote authority (such as the ESRC website). I argue that the potential of a medium is one matter and that how these are used is another.

The Range of Modes Made Available

Although the potentials of medium is one matter and how they are used is another it is true to say that in general a range of modes are more easily facilitated by the medium of the computer than the book. The book has a recent history of association with one dominant mode that is writing (although other modes are always in play). In contrast computer-based technologies have been developed at a point where multimodal communication is common and without a 'mono-modal' history of association. CD-ROM and web-based technologies typically make available a wider range of modes at one time than a book. While film makes available many of these modal resources it does not have the medium's potential for interactivity (via keyboard, mouse, and joystick) and these modal combinations are not available productively for the reader. The process of production in the medium of film and video was mode specialised (e.g. lighting, sound, and editing) each of which was in the control of distinct professional domains. The facilities of computer applications such as iMovie, animator, and Premier provide the possibility of the productive use of a full range of modes and roles.

Multimedia with its branching structure, its convergence of media, its hypertext connections and multiple webs, makes it unlike single media forms and, I suggest, creates routes out of subject-specific channels.

(Sinker, 2000: 188)

The merging of production roles and availability of modes afforded by the facilities of the medium of computers may as Sinker suggests have an impact on the boundaries of school knowledge.

In this thesis I explore the kinds of mode and the range of modes made available in the technologies of different media and the configuration or design of the interaction between modes. The interaction of image and writing on screen is explored in a number of ways. This includes analysis of the percentage of the screen allocated to each mode, the compositional position of each mode, the links made between image and writing, and the meanings that each mode realises.

The Potential for Interactivity

Examining the options available to the user of a computer application enables the potential for interactivity to be analysed. Here the focus is on what resources for action the user has, what can be altered, re-made, edited and when these options are made available and when they are not. The analysis of student interaction explores when and how students engage with these potentials. This includes the limited interactivity of a CD-ROM in which the user can shape a text through its reading, through the order it is read in, and the elements selected or by passed. As well as the interactivity offered by a computer programming application in which the user can import images and sounds to bring together a range of objects and behaviours to construct a game. 'Interactivity' broadens the possibilities for inter action in the shift from book to screen.

The computer screen, unlike the cinema screen or (until very recently) the TV screen, is a surface of reading/reception and of writing/production.
(Burn and Parker, 2002)

With the book the reader cannot write back, and the reader cannot modify the text in any way other than in inner interpretation. The facilities of computer technologies

afford the potential for readers to modify some texts, and in the case of reading a CD-ROM or web based text the reader is a producer of the text through their interaction with it – the route they produce the text through. Computer applications offer different degrees of interactivity: from page turning, to feedback to learner, the freedom to browse and surf, simulations (responds to users actions), and virtual worlds (learner experience of an environment) (Clarke, 1997). The potential for interactivity is admittedly one that is not always used effectively. Computers also have the facility to reduce the interactivity of the user, for example, to determine the time a screen is displayed for and to ‘move’ the reader on to the next screen.

Structure and Hyperlinks

In this thesis I analyse the structure of the computer applications as a semiotic resource, in particular the way in which the transformation of a text from one medium to another is transformed through the use of structure. For instance, the narrative structure of the novel *Of mice and men* (Steinbeck, 1937) discussed in Chapter Four, is significantly changed in the move from the medium of the book to the medium of the CD-ROM. This includes a shift from paragraphs and pages to blocks of text and screens, the introduction of video clips and a character guide, hyperlinks to factual definitions of slang words in the text, and hyperlinks to a map and historical information on the location of the novel. I also explore the design of hyper links and routes to create relations and continuity or discontinuity between elements (Lemke, 2002). The ways in which screens of information can be linked (their ‘hypermodality’) in the medium of the computer contributes to the meaning potential of computer applications.

It is not simply that we juxtapose image, text, and sound; we design multiple interconnections among them, both potential and explicit.
(Lemke, 2002: 300)

The structural links between screens can take a number of forms, such as: index-like lists, nested structures, tree structures, semantic links (linking for example, a car with transport: the link 'is' 'kind of'). Along side the software or web designer's selection of these organisational structures, semiotic potentials such as direction, distance from the home page (position in the structure), what is linked to what (i.e. classification), and the contrast between the styles of different page, combine to realise meaning. For example, narrative is a structure used by designers to present information which avoids the explicit navigation metaphor. Narrative involves the story being told (content) and the conditions of its telling (structure and context) (Oren et al, 1990; Don, 1990). Characters or guides are sometimes used to suggest story-like structure and to shape the mood of an application. Information, facts and instructions are often embedded in the narrative structures as are the point of view of the storyteller and reoccurring cultural themes. Genre is, as I will show, another tool for the organisation and presentation of information on screen.

The Screen as a Site of Display

In this thesis I explore the different sites of display of the page and the computer screen, in order to examine how people's engagement with these can bring-forth different kinds of expectation and forms of engagement. In Chapter Four, for example, I focus on how the move from the medium of the book and the page to the medium of the CD-ROM and the screen can enable the 'novel as CD-ROM' to be 'read' as 'book', 'film', 'cartoon', or 'musical'. In short how the genre of a text can be changed by a user's engagement with the facilities of the medium and the screen as a site of display. Throughout the thesis I argue that the computer screen features in students' construction of meaning through their gesture with the screen itself and the construction of different kinds of spaces on screen. I show how the screen is brought into students' multimodal meaning making in a variety of ways.

There are many distinctions between the computer-screen and the page, including its size and shape, the potential for dynamic representations, and permanence. The shape

of page and screen are different: page is portrait and screen is landscape. The visual impact of page and screen is different. The historical associations are different. How information is arranged is different. The page is essentially the domain of writing, so even where image fits onto the page it is fitting into the organisational rules of the written. The screen is the domain of the visual and is organised according to the organisational rules of the visual. In addition, pages come in standard sizes within a limited range, whereas the potential to scroll releases the screen from some of these limits.

In contrast to the static representation of elements on the page (with the exception of pop-up books) the screen has the potential to represent elements dynamically.

The screen is impermanent, organic, transient. Its content is electron and phosphor dot, painted in quantum events, constantly refreshed...Paper is solid, hard, irreducible. Once applied to that surface through printing, text is frozen, but until that time it is dynamic and alive on screen.
(Swigart, 1990: 139)

The page can combine the modes of image and writing, in contrast, the screen can combine image, moving image, writing, speech, and sound, and other modes. While the page is usually monochrome the screen has the potential for full colour display. I argue that the screen offers different modal resources for meaning making than the page.

As the ink hits the page the meaning and structure of a text is made permanent (an individual can change the text, she or he can read the text in an order different than that intended, but they can not change the structure of the text itself). This is not so with a CDROM or Web page. These media have a permanent structure of links and webs and connectivity and through their engagement with these the reader produces and restructures the text. There is no single default reading sequence. Finally, the

navigational markers of the page (page numbers, contents page, and index) differ from those of the screen.

Page and screen look different, they feel different, and they mean different. The unsettled space between what has been (the page) and what will be (the screen) provides a communicative potential for reshaping modes and their relations, in particular, the relations between writing and visual image. This focus on the relationship between writing and image is addressed through Chapters Four, Five and Six. Both the page and the screen can be seen as the critical interface or semiotic resource that mediates between the author/designer of a programme or book and its reader.

The Concept of Sign

Within multimodality the concept of sign is multimodal, motivated and transformative. Multimodality and social semiotics draws attention to the social agency of people in meaning making. It looks at how people realise meaning through their selection of semiotic resources (meaning potentials) from a range of modes as signifiers for what they wish to express in specific social contexts. Hence my analytical focus in the thesis on computer applications as semiotic texts designed to make meaning, and the focus on student interaction with these to realise new meaning.

I understand signs as being produced by the motivated conjunction of forms and meaning and from this standpoint I theorise the relationship between signifier and signified as motivated. The concept of the 'motivated sign' and 'interest' introduced in the previous chapter serves to shift the focus from the system of signs to the process of meaning making (signs). In this thesis I therefore analyse the relationship between signifier and signified as a trace of the characteristics of the producer of the sign (as a socially located person) and the entity to be represented.

I use 'activity theory' as a framework to think about sign making and learning beyond the individual. This enables the social forces that 'lie behind' (and produce) a student's interaction with a computer in a school classroom to be held in mind throughout the multimodal social semiotic analysis presented in the thesis. I use the framework of activity theory as theoretical lens for thinking about the classroom and to consider the rules, norms, and social roles of people within communities that underpin semiotic mediation and sign making. I address the question of how the computer as a semiotic tool can re-mediate learning throughout the analysis. The concepts of a 'subject', 'object', and 'mediational tool' are used as a basic framework for thinking about how students refer to the material for study or the problem space that they are working with and how they bring the tools of the computer to bear on it. The concepts of 'rules', 'community' and 'the division of labour' enable me to understand semiotic mediation in the wider social context of school learning and to examine how new technology re-mediate the values, roles, and community of the classroom and the curriculum. That is I analyse students' sign making within the activity system of the school.

Throughout the thesis I treat signs as the result of a sign maker's (socially situated) selection of criterial aspects of what it is that they wish to signify. I analyse the relationship between meaning and form as constantly realised in the process of sign making and it follows from this that I treat signs as always newly made. Understanding signs as motivated and transformative raises the matter of what semiotic resources are available to choose from given the meaning that the sign maker wants to make in a specific context. I examine how students take up and use these resources, transform them and design meaning in Part II of the thesis. In this way signs are interpreted as one kind of evidence of the sign maker's interest and cognitive work. The fundamental connection between external material signs, inner signs and cognitive development supports this. Computer applications are interpreted as one kind of evidence of the choices made by their makers. The computer applications that I examine are viewed both as the actualisation of the design of the

maker – a multimodal semiotic text, *and* a collection of meaning potentials. Students work with these potentials to realise new meanings. The student's material expressions, signs, images, writing, gestures, and so on are interpreted as an expression of their engagement with knowledge: one kind of evidence of what their thinking and learning may have been like.

Multimodal Data Collection, Sampling and Transcription

The Schools and Lessons

The criteria used to select the schools for the study was the active use of computers in teaching and learning. The literature on computer mediated learning and my experience of research into school Science and English shows that computers are not well integrated into all schools. For this reason only schools known to be actively using computers were approached. (The Information and Communication Technology P.G.C.E. tutors at the Institute of Education supplied this information.) Five secondary schools were recommended and contacted.

The head teacher of Science, and English was contacted in each school and invited to participate in the study. All responded to the invitation positively although not all could provide access to teachers working with new technologies. The data is collected from three schools all of which are state schools and one of which is a Specialised Technology School. The teachers who took part in the study volunteered themselves. The aim of the thesis is to observe the use of new technology 'as it happens' in the school, for this reason I did not stipulate the year group, curricular content, and the type of computer application to be used in the case of school English and Science. The data discussed in Chapter Five of the thesis is from 'The Playground Project' a European Union research project¹. The Playground Project data was collected from an

¹ The playground project is a research project directed by Professor Noss and Professor Hoyles at the Institute of Education, University of London. I was involved on an informal basis with the project and contributed to discussion of the semiotic design of the interface for the applications used. On this basis the directors agreed to allow me access to the project data.

after school computer club at an Inner London Primary school and project workshops. The project makes use of the computer application Toontalk that makes available a range of modes and introduces the subject of games within the context of the math curriculum in ways that offer an interesting challenge to multimodal theory.

I selected the three curriculum subjects, English, Mathematics, and Science as the focus for the thesis for two reasons. First these subjects epitomise what the government and others see as the core curriculum subjects (as is emphasised by recent government policy on literacy and numeracy and the more general drive to increase education in the sciences). Second these subjects provide the opportunity to explore the hypothesis that modes feature quite differently in the construction of school knowledge within different subject areas.

I analyse three illustrative examples of technology mediated learning in this thesis. The first set of data (discussed in Chapter Four) focuses on a series of English lessons with a Year 10 class (students aged 14-15 years). The lessons focused on the study of the Steinbeck novel *Of Mice and Men* (1937) a set text in the English GCSE curriculum. The focus of the lessons is on the production of course work that focuses on the entity character that is central to school English. A series of five (one hour long) lessons in which the students worked with a CD-ROM from the Steinbeck series (1996) were video recorded. Information was gathered about the module from discussions with the teacher. The second set of data (discussed in Chapter Five) focuses on a series of three after-school game sessions with two year 5 students aged 7 – 8 years. This data is drawn from the Playground project. Video and audio data on the three sessions (each one-hour in length) was gathered. During these sessions the students work together to design and build a game in the computer application Toontalk. Toontalk is a computer programming application written in a Turing equivalent 'language'. The focus of the data and the analysis presented in the chapter is on the construction of the entities 'rule' and 'bounce' within the context of the game. The students' initial design of the game on paper was photographed. A follow

up interview conducted with one of the students about their game provided another source of data. The third set of data (discussed in Chapter Six) focuses on a double science lesson with year Seven students (aged 11- 12) working with the CD-ROM *Multimedia Science School*. The lesson is on the topic 'states of matter' and my analysis examines the ways in which the multimodal resources of the screen reshape the curriculum entities 'states of matter' and 'particles'. During the lesson the students work first on individual computers, and then with the CD-ROM as displayed on an interactive whiteboard. Video recordings of the lesson form the main data for the chapter, along with the students completed worksheets and the lesson plans designed by the teacher.

Data Collection

A multimodal approach to learning requires a method of data collection that facilitates a focus on all modes in the classroom. Video recording offers a method for recording classroom interaction given the speed and complexity of recording gesture, body posture, talk, and the use of image etc. in the classroom (Lomax and Casey, 1998). It also enables repeated viewing of the data and provides a record from which all the modes can be transcribed. Two video cameras were used. One camera focused on the interaction between students, the computer, and the teacher. The second camera was set up to capture the data displayed on the computer screen.

Heath (Heath and Luff, 1993; Heath et. al., 2002) suggests that the most effective use of video recording as a method of data collection is to set up the cameras to record phenomena and for the researcher to leave as this lessens the impact of the research on the phenomena being studied. This was unsuccessful in the classroom for two reasons. First the demands on the teacher within the lesson meant that they could not be relied upon to turn on and operate the camera/microphone. Second students and teachers constantly shift position in ways that make it impossible for a static camera to capture the activity of the classroom and the contents of a screen in the detail required for the analysis. For these reasons I operated the cameras in the classroom. It

is not possible to know the impact of the researcher and cameras on these lessons however the impact of the study on the events recorded may be ameliorated by the particularity of the school classroom. School classrooms differ from many other research contexts as teachers and students are familiar with having strangers in their classroom including OFSTED inspectors, evaluators, teacher educators, and student teachers. Students were given the option of not being video recorded (which none of them took up). In the end it is impossible to observe the world without being in it without raising serious ethical issues, and the questions addressed in this thesis are of the kind that, I want to suggest, where my presence in the classroom was unlikely to reshape the data in significant ways.

My presence in the classroom enabled me to collect observational data. I used observational notes to record interactions ‘off camera’, comments made by the teacher and students, and the spatial arrangement of the classroom. This data provides a useful reminder that video recordings (like any data) are a partial representation of events. Alongside this video and observational data the texts made by students during the lessons were collected. In order to explore the potentials that the students were working with in the classroom the computer applications that were used during the lessons were collected for analysis. Documents that were used in the lesson for example worksheets detailing the task set by the teacher were collected, along with documents that informed the lesson in a less direct way, such as the national curriculum.

Sampling

Multimodal analysis is intensive in character and as a result I sampled the video data of each series of lessons to select instances (episodes) of learning for analysis. In order to do this I viewed the video recordings along with the observational notes to produce a descriptive account of each lesson. These descriptive accounts include multimodal commentary on the computer screen, curricular content, and the practices of the students and teacher. The process of viewing the videos, and logging and

organizing the data generated criteria for sampling the data as well as analytical insights and questions. The sampling criteria are purposive and reflect the research questions that I set out in Chapter One of this thesis. The data was sampled for critical instances of:

- Learning in which the multimodal resources made available by computer applications appears to impact on the shape of curriculum knowledge.
- Student engagement with these resources in ways that appears to reshape school practices.
- A clear modal shift such as the move from image based to writing based learning.
- Information being ‘transduced’ across modes.
- The different ways that the students engage with the resources that the computer applications make available to them.

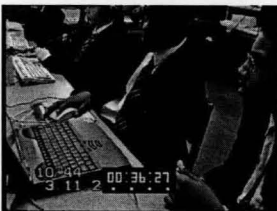
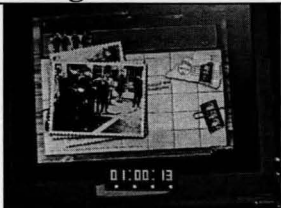
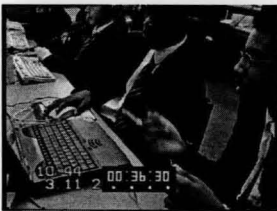
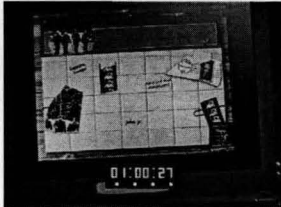
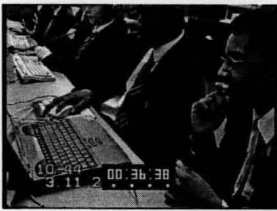
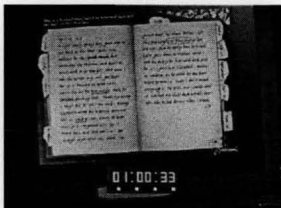

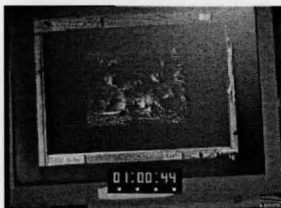
I applied the above criteria to the data in order to identify episodes for analysis.

Multimodal Transcription

Transcripts are a representation of an event. Making a transcript is therefore a theoretical practice that marks what is theoretically important or unimportant to the transcriber. A transcript shapes that which will be attended to and it shapes the analysis by making some aspects ‘present’ for analysis. Moving beyond language requires a transcription process which takes account of all modal resources that are in focus and the means to examine how these resource work together to make meaning.

To achieve a multimodal transcript a theoretically integrated set of descriptive dimensions highlighted as important in the literature are used. These include dimensions of the modes of gaze, gesture, body posture, the semiotic objects of action, image, and speech (Bateson, 1987; Bitti and Poggi, 1991; Merlau-Ponty, 1969; Crowder, 1996). Viewing each video sample a transcript is made recording each mode with time as an anchor as shown in figure 3.1.

Figure 3.1: Excerpt of multimodal transcript of two students working with a CD-ROM

Time	Plane of the classroom: students			Plane of the screen		
	Video image	Action/gesture	Speech	Image	Action/gesture	Speech
0.36		B & D Sitting back in chairs	T: in a minute can you click onto the section you liked the most			
		D: hand covering –holding mouse				
		B: point screen D: clicks on bar, brings up menu	B: OK, lets go, lets go to...			Voice reads diary
		B: reading the menu D: turns from screen and looks at B D: clicks diary B: points at screen D: clicks mouse – closes diary, selects novel B: picks up pen and starts to write	B: ok. I didn't like the diary D: you didn't like the diary? B: go to novel D: oh sorry B: go to novel T: can you write down the bit you disliked the most			Sound track – dialogue 'guys like us...'

The transcript provides a 'thick descriptive' multimodal account of the video data. There are different ways of organising multimodal transcripts. Transcripts can be in the form of 'play scripts' where all the modes are merged and described in writing. Moving away from a focus on written transcripts multimodal transcripts can attempt to represent an event via a series of images, such as stills from video recordings, in which what is said is presented along side an image of the event (Norris, 2002). However, while such transcripts present a visual snap-shot of an event the modal affordance of still image means that it is difficult to capture the detail of gesture and movement over time and to provide an 'analytical description' of an event. An alternative form of transcribing is analogous with the format of a musical score in which time runs from left to right and each of the modes is described along this horizontal time line, each mode occupies a row of the 'score'. This format introduces the useful visual analogy of the 'orchestration of modes', and the 'rise' and 'fall' (foregrounding and backgrounding) of specific modes in the multimodal ensemble. A third option is to organise the modes in separate columns, with time as an anchor.

In order to analyse the data I transcribed it by attending to each of the modes in separate columns. This separation of modes in the transcript is useful to address the question of how different modes contribute to computer mediated learning. It enables the analysis to focus on each mode in turn. The use of time as an anchor in the transcripts enables the analysis of how different modes interact at a specific moments in time by reading across the columns. For analytical purposes I used these multimodal transcripts to record the interaction of students with the screen as shown in figure 3.1. I also used this way of transcribing to analyse the resources 'on screen' (as in figure 4.3 in Chapter Four). In a sense this latter transcript (Figure 4.3) is a detail of the transcript shown in figure 3.1. The transcripts allow a different focus on computer mediated learning. The transcript detailing student interaction with the computer screen shows their actualization of the potentials of the CD-ROM their making of the text by their movement through it. The transcript detailing the resources of the CD-ROM shows the semiotic potentials that the CD-ROM makes

available to the students in the lesson. The transcripts provide an initial analytical description of the classroom data. These transcripts are used alongside the video data. For the purposes of the 'presentation' of the data in Chapters Four through to Six in some cases the transcripts are presented in to show speech, gesture, and gaze as a series of lines (similar to a kind of musical score). The speech is underlined to indicate where gesture and so on co-occur. The decision to use one kind of transcription for analysis and another for presentation helps to re-present the analytical process in order to make the point of the discussion more clearly available to the reader.



In this chapter I have drawn on the theoretical framework discussed in Chapter Two and the aims of the thesis outlined in Chapter One in order to describe the framework for the analysis of the data presented in Part II of the thesis. In the following chapters I focus on the analysis of specific instances of technology-mediated learning in school in English, Mathematics and Science.

Part II:

Multimodality and Technology-Mediated Learning

4. The Multimodal Reshaping of Curriculum Entities in School English in the Move from Page to Screen

Introduction

In the move from page to screen a range of representational modes (including image, movement, gesture, and voice) become available as meaning-making resources. In this chapter I focus on the reshaping of the entity ‘character’ in the transformation of the novel *Of Mice and Men* (Steinbeck, 1937), to a CD-ROM (1996). Through detailed analysis I demonstrate that the shift from written page to multimodal screen entails a shift in the construction of the entity ‘character’. I show that students’ interaction with the resources of the CD-ROM as a multimodal text demand that ‘reading’ and the process of learning within school English be thought of as more than a linguistic accomplishment.

As highlighted earlier in Chapter Two, research on technology-mediated learning has tended to focus on people’s talk and practices with and around the computer rather than on the representational resources of computers. This chapter is concerned with the representational resources of the CD-ROM as it appears on the screen as well as people’s interaction with these in the context of school English.

The Notion of ‘Character’ in School English

This paper draws on video and observational data from a series of five English lessons with a Year 10 class (students aged 14 –15 years) at an Inner-London Secondary School (see Chapter Three for details of the data and data collection process). These lessons focus on the study of Steinbeck’s novel, *Of Mice and Men* (1937), a set text in the English GCSE curriculum. The entity character is central to school English. The entity character is highlighted in the history and development of

English as a school subject. It is also emphasised by its prominence in the National Curriculum.

As an academic subject English began in the working men's colleges of Britain. The emphasis was on the transmission of moral values to the working class. That has been an essential part of the ideological project of English advanced by the work of, among others, F.H. Bradley and the F.R. Leavis (Eagleton, 1983). For the Leavisites, as for others (Marxists for instance), literature and society were intimately bound together. In such theories the very stuff of ideology is thought by people to be reflected in great works of literature. In colleges and schools, literature that enabled the communication of strong moral values through close engagement with such texts was encouraged. Such literature, it was thought, offered the potential for students to discover a spiritual home, and ultimately to discover the self through reading it "...[to] know how they came to be as they, very idiosyncratically, are." (Kermode, 1979:p. 15). This notion of literary character is realised in Steinbeck's writing. Throughout the 20th century, the traditional notion of literary character as a means for knowing oneself has underpinned an oblique form of moral education in British schools. The residue of this legacy persists in the English curriculum's inclusion and exclusion of authors, and texts such as Steinbeck's *Of Mice and Men*.

The study of set texts is a central element of school English. GCSE English coursework and examination includes the demand for responding to a set text by recommended major authors. The English National Curriculum programme and assessment schema highlight 'character' as a core entity. Understanding character is explicitly specified as central to a critical and creative response to a range of texts. Students are expected to demonstrate how character is constructed through an author's choice and style of language. Students are also assessed on their ability to make comparisons between the characters in a text and their role in the narrative, and to demonstrate the motivation and behaviour of a character through the analysis of a text (DFEE, 1999).

In the instance discussed here, the teacher had focused on the entity character in the course work that she had set the class. The course work set was to write ‘a day in the life’ of a character from *Of Mice and Men* (1937). The students had to select a character of their choice for this work.

The focus on character in both official documents and policy documents and in classroom versions of English indicates the importance of understanding how character is realised in the CD-ROM. I give an overview of the content and structure of the CD-ROM in the next section. I describe the multimodal reshaping of the characters firstly in the ‘Novel as CD-ROM’ and secondly in the Dossier section of the CD-ROM. Through this analysis I show that the traditional notion of character described above is also reshaped (gets a new form) in the move from page to screen. I return to the question of what this reshaped character might mean for learning later in the chapter.

Overview of the CD-ROM

The CD-ROM version of, *Of Mice and Men*, is organised into five parts: Novel as CD-ROM, Biography, Map, Diary, and Dossier. Each of these parts of the CD-ROM is selected from the opening screen. These five parts of the CD-ROM draw on a range of modal resources in order to focus on discrete aspects of the study of a text.

The ‘Novel as CD-ROM’ offers two viewing options titled - ‘Text’ and ‘Visual’. The Text option, as the title suggests, is a written text. The other option, even though it is called the ‘Visual’ option, is actually multimodal. The ‘Visual ‘ option consists of video clips, audio clips and screens with still images and writing. It also includes a character guide, Bindy, in the form of video clips of an actor, which offers a spoken commentary at various points. In addition there are visual hyperlinks (in the form of words circled in red, italicised, or underlined) which link to other sections of the CD-ROM (such as the Map part of the CD-ROM, or commentary on the text).

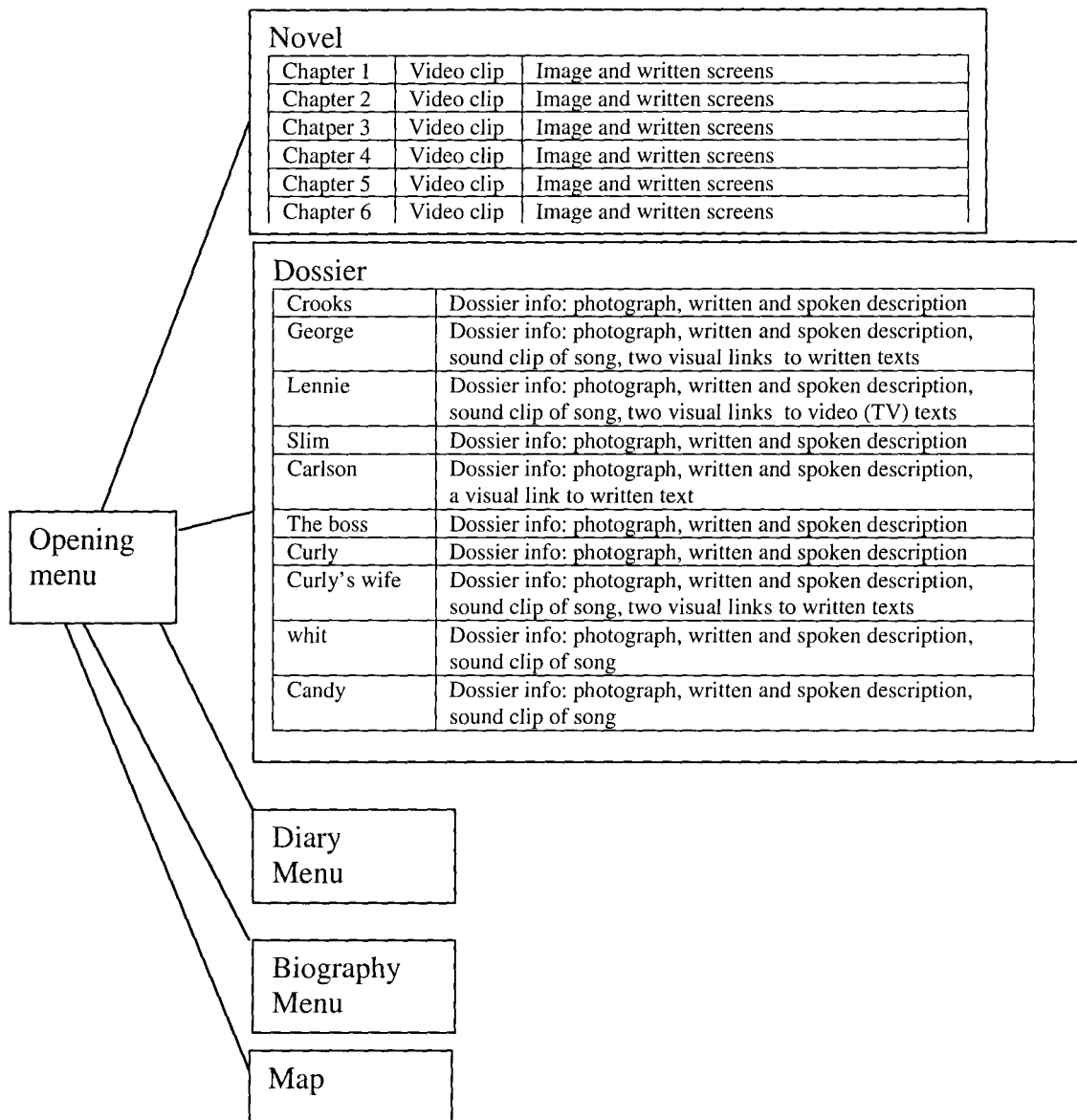


Figure 4.1 Map of the CD-ROM

The 'Text' version of the 'Novel as CD-ROM' uses a Times font on a plain white background that produces a 'visual plainness'. The writing in the 'Visual' option uses a more elaborate font - Apple Chancery (figure 4.2). The choice of a font that

visually references 'handwriting' visually signals 'individual' (personal) aspects, such as age, authenticity and personal status of the writing (typography is discussed briefly later in the chapter). The video clip in each chapter brings the modes of speech, voice, music, movement and gesture into play. The 'Novel as CD-ROM' also includes a series of still image and written text screens each of which is filled with a still image, and a block of writing.

In this chapter I focus on the Visual option of the 'Novel as CD-ROM', for two reasons; first, it is the default option on the CD-ROM, and, second, it is the option that the students whom I observed used.

The Novel as CD-ROM

In exploring the modal realisation of character in the CD-ROM as it appeared on screen. I treat the 'Novel as CD-ROM' as a transformation of the printed novel. The 'Novel as CD-ROM' is the product of designer's modal re-shaping of the 'novel' from the medium of the book to the medium of the CD-ROM. In that process the entity character is transformed in significant ways.

Many novels, including *Of Mice and Men* have been transformed into film. The move from the mode of writing to the modes of image, speech, gesture, movement and so on is the root difference in this transformation (Bluestone, 1973). The medium of book and the medium of film have different properties including different origins, resources for making meaning, relations to times and space, conventions, and audiences. The resources of transformation in the move from the medium of the book (*Of Mice and Men*) to the medium of the CD-ROM differ from those of the move from the book to the medium of film.

The medium of the CD-ROM has different properties to film. This difference allows it to both transform and maintain the presence of the original text. The question of what is maintained and what is changed in this transformation is addressed in the

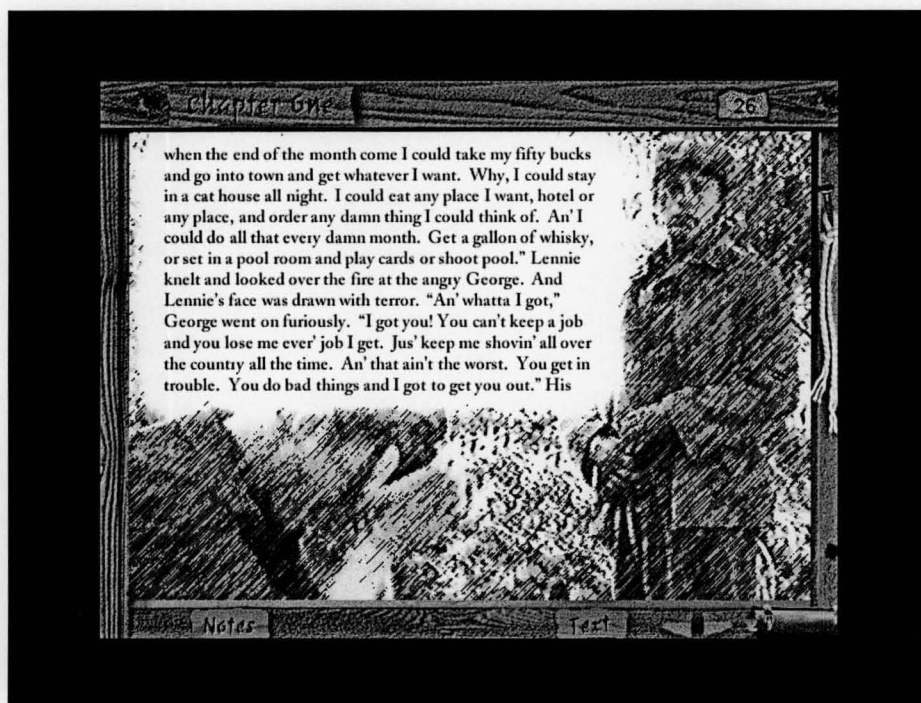


Figure 4.2 Screen from visual version of the 'Novel as CD-ROM'

detailed analysis of the 'Novel as CD-ROM' presented in this chapter. The medium of the CD-ROM explicitly frames the novel as a pedagogic text and the effects of this re-framing on the entity character and novel are discussed throughout the analysis.

The transformation of the novel, *Of Mice and Men*, from printed page to electronic screen via the medium of the CD-ROM draws on the modal resources of image, sound, and action in three ways. First, it involves the transformation of writing into multimodal video clips using voice, music, movement, body-posture, gesture, clothes, composition, and editing. Second there is the inclusion of still image throughout the 'Novel as CD-ROM'. Third, there is the addition of the video character guide, 'Bindy', to the 'Novel as CD-ROM'. The modal resources reshape the students' 'reading' of character.

The analysis presented in this chapter describes the meaning potentials made available via the multimodal transformation of the entity character from the novel in the medium of book to the novel in the medium of CD-ROM. My analytical focus is at two levels. First, at the level of the resources of the CD-ROM as they appear on screen; and second at the level of a reader's interaction with these resources. I focus on Chapter One of the 'Novel as CD-ROM' to describe these modal changes in detail. Chapter One introduces the characters Lennie and George and narrates their journey to the Speckle Sugar ranch. This chapter is typical of the relationship of the original novel to the 'Novel as CD-ROM'. The chapter is also typical in its use of modes and organisational structure (shown in figure 4.3). The opening screen is a multimodal video clip consisting of speech and the visual representation of gesture and movement, the screens are realised through the modes of image and writing, and the character guide bindy is represented through the modes of speech, music, gesture and movement.

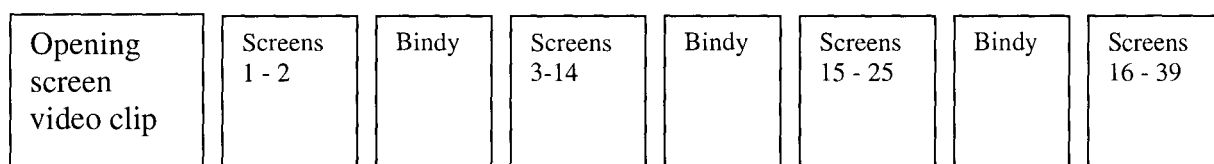


Figure 4.3 The structure of Chapter One of the 'Novel as CD-ROM'

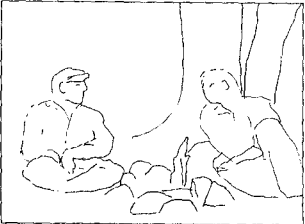
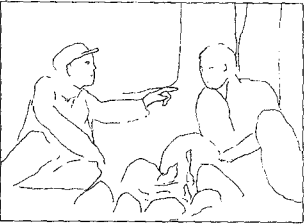
From Writing to Multimodal Video Text

The CD-ROM version of the chapter opens with a video clip (lasting fifty seconds) of the 1992 film of the novel. It shows the characters George and Lennie sitting by a campfire, talking. This scene in the CD-ROM draws on pages 15 - 16 of the printed novel (the chapter in the book is 18 pages in total). In other words, the 'Novel as CD-ROM' effectively 'opens' near the conclusion of the chapter. The effect of the move from writing to multimodal text is described in the transcript (shown in transcript 4.1)

The Visual Representation of Gaze, Gesture and Movement

The transformation of the scene of the characters George and Lennie around the campfire, from page to screen, opens the possibility for re-presentation through the modes of gesture, movement and gaze rather than that of writing alone. The choice of a video clip as opposed to an audio clip can be seen as motivated by modal considerations. Gesture, movement and gaze offer different resources for meaning making than does sound. Movement as a mode offers different possibilities than sound for realising rhythm and pace (fast/slow, smooth/jerking), it has spatial dimensions (close/distant), and directionality (up/down, left/right, in/out). Just as in sound, there is the potential for silence; there is also the possibility of stillness in the 'lack of movement'.

Actional modes are used in the 'Novel as CD-ROM' to construct the characters George and Lennie as different. The character George maintains the same body

Book text	Screen image (elements, setting, clothes, composition)	Actional modes: Gesture, posture, movement, gaze	Speech	Voice
<p>George's voice became deeper. He repeated his words rhythmically as though he had said them many times before.</p> <p>"Guys like us, that work on ranches, are the loneliest guys in the world. They got no family, They don't belong no place. They come to a ranch an' work up a stake and then they go into town and blow their stake, and the first thing you know they're poundin' their tail on some other ranch. They ain't got nothing to look ahead to."</p>		<p>Edit one</p> <p>Long – social shot</p> <p>Lennie and George look at each other, George leans in slightly.</p> <p>Both sit, George stays still, while Lennie moves a little.</p>	<p>Guys like us, that work on ranches, are the loneliest guys in the world. They got no family. They don't belong no place. They ain't got nothin to look ahead to.</p>	<p>Slow voice, each word separated, regulated. Even tone, calm, rhythmic.</p>
<p>Lennie was delighted.</p> <p>"That's it – that is it. Now tell how it is with us."</p> <p>George went on. "With us it ain't like that. We got a future. We got somebody to talk to that gives a damn about us. We don't have to sit in no bar room blowin' in our jack jus' because we got no place else to</p>		<p>Edit two</p> <p>Lennie springs/jerks forward and grabs at the air.</p> <p>George makes a soft rolling gesture with his hand.</p>	<p>But but not us George, tell tell about us</p> <p>Well we ain't like that. We got a future. We got somebody to talk to that gives a damn about us. Them guys gets in jail they can rot for all anybody gives a damn.</p>	<p>Quick voice, stuttering, mixing of words, fast, excited.</p>

Transcript 4.1

posture and position throughout the video clip (Transcript 4.1 image (a)). He is represented sitting by the fire resting against a rock with his legs stretched out in front of him, and leaning slightly toward the character Lennie. He looks steadily at and maintains the same direction and focus of gaze throughout. On one occasion he makes a soft rolling gesture with his hand. In contrast, the character Lennie is represented as sitting leaning against a rock with his knees brought up under his body. As the character Lennie starts to talk, he lunges forward, shifting the weight of his body forward, and leans across the fire and prods George on the shoulder (Transcript 4.1 image (b)). As he talks he moves his hands in a series of jerking gestures, and shifts his gaze from George to the surrounding woods (Transcript 4.1 image (c- d)).

This re-presentation of the two characters' body posture, movement, gesture, and gaze serves to polarise them. The character George is represented as still, his gaze is steady, and his posture relaxed (his body stretched out), physical qualities associated with calmness and stability. His leaning in toward the character Lennie and his close spatial distance serve to realise an intimate engagement with the character Lennie. George's soft rolling gesture is slow and gentle - a sign of control and ease. In contrast the springing, lunging movement, gaze, and 'prodding' gestures of Lennie represent him as unsettled, volatile, and unaware of danger (leaning across the fire). The posture of Lennie, his legs pulled tight into his body, is a closed tight one and signals the tension of the character. His jerky gestures are fast and forceful and indicate both his strength, and his lack of control. The character George is depicted as gazing at Lennie, a transactional reaction in which Lennie is the goal. In contrast Lennie's gaze at George is wavering and darts around towards the woods, his gaze is unclear, and unfocused a multimodal sign of his lack of concentration. These transformations of the characters serve to reinforce the qualities of the rational adult character of George and the emotional child-like character of Lennie – who literally 'can't sit still'. This construction of the characters through actional modes shapes the viewer's relationship to the characters and understanding of their relationship.

Distance of Shot

As discussed in Part I of the thesis, in everyday interaction the culturally established norms of social relations determine the distance we keep from one another to suggest different degrees of intimacy or formality. This resource is used to indicate the relationship between the characters George and Lennie and the relationship with the viewer (this is discussed in the next section). In the first shot Lennie and George are represented from some distance, - the long shot, which is a conventional shot for setting the scene. The second and third shots are closer shots - medium shots, which show George and Lennie from the waist up (Transcript 4.1 image (c)). The increased closeness of these shots realises the characters' relationship, and perhaps the potential claustrophobia of George as Lennie gestures towards him (and the viewer).

Point of View

The camera encodes a viewing position, both in terms of distance, and in angle of representation (as discussed in Part I of the thesis). That is, the viewer is 'placed' in a particular viewing position to the things represented. The viewer is not bound to accept the viewing position encoded by the maker of an image. Viewers bring different ways of seeing to an image, and their meanings are the result of their negotiation, or even rejection, in the process of interpreting/engaging with an image at different historical-social moments (Rose, 2001). Nonetheless, viewing positions are encoded in an image and this is the resource offered as the basis for the negotiation of meaning. In the video clip, the point of view of the first shot shifts from a frontal angle (objective) to a slightly oblique angle in the second shot – an over-the-shoulder shot. (This is the convention of representing a static dialogue scene in film.) This shift in angle 'places' the viewer close to the left of George. The visual focus is on the character Lennie as he talks and gestures. This contrast of angles (combined with the move in distance) serves to emphasise and objectify the action of Lennie from a viewing point close to the experience of George. In the third shot (Transcript 4.1 image (d)) the viewing position is reversed: the camera (viewer) is

positioned to the back right of Lennie and the visual focus is on George as Lennie talks. The viewer is now looking at 'the visual experience of the character Lennie', the calm smiling face of George, who remains still and attentive. This use of angle and distance, a standard film device, is to visually construct viewer empathy with George's 'experience' and the objectification of the character of Lennie. It also serves to further differentiate the characters through visual means.

Clothes

Both in the book and in the CD-ROM clothes are used to construct the relationship between the characters in different ways. In the book George and Lennie are represented as both dressed in denim trousers and denim coats with brass buttons. It is the characters' physical features, their height and size, which distinguish them. In the 'Novel as CD-ROM', George and Lennie are re-presented through their clothes (in addition to their height and build) to be different. In the CD-ROM the character Lennie is dressed in a flat cap and loose fitting dungarees cut from a pale blue light-weight denim. George is dressed in a dark brimmed hat, a well fitting dark brown jacket and jeans, and a check shirt. Clothes are used as social marker of visual difference. Lennie is dressed in clothes that are traditionally worn by children (and in the era of the book, the working class). George is dressed in clothes generally worn by adults. That is their clothes are associated with the power of the social position of child and adult. In this way, clothes are visual signs used to suggest Lennie's dependence on George.

The shared social position of the characters Lennie and George, a significant feature in the novel is transformed in the visual mode of video on the CD-ROM. The use of clothes to visually position George and Lennie's relationship as an adult-child relationship presents a filter through which George's anger and his attempts to control the character Lennie in Chapter One (and throughout the novel) can be read as acceptable within a contemporary context. The imbalance between the two characters is visually highlighted. The nature of the friendship between George and Lennie is

visually placed in the context of 'family', which reduces the potential for their friendship to be read by a contemporary audience as a gay relationship. Interestingly the 'Novel as CD-ROM' reproduces the original text from the novel in the written mode and so the visual re-presentation of the characters and the written representation of them stand in tension.

Design

Composition and editing are means for the visual design (organisation) of a range of modes in the video clips. They provide a range of resources for the arrangement of elements in a visual space, in this instance the visual space of the screen. In the video clip, the two characters could be represented on screen at the same time, or the camera could move between each character (depending on who is talking). One character could be placed in the foreground or background, on the left or right of screen, or in the centre. Designers and viewers interact with these resources of arrangement (read and make sense of them) to construct meanings. The way in which elements are placed in relation to each other on screen produces relations between them that express different potentials for meaning. Camera movement between the two characters, for example, may be used to suggest dialogue (this may be realised in the mode of gaze). The compositional framing of two characters on screen may visually realise intimacy or unity.

In the first shot (Transcript 4.1 image (a)) the screen-space can be 'divided' into three vertical 'zones'. Each of these 'zones' is occupied by a different element. The character Lennie occupies the left 'zone' of the image, the fire is in the middle 'zone', and George occupies the right 'zone' of the image. Looking at the screen as a triptych compositional arrangement of space in this way suggests that the relationship between the characters Lennie and George is mediated by 'fire', a symbol of warmth. During this shot, George consistently occupies 'his own space'. In contrast, Lennie moves across the fire to gesture and touch the character George in a kind of lunging movement. Lennie's movement from the 'zone' he occupies into the 'zone' occupied

by George disrupts the equilibrium of the visual arrangement. It is this movement which heralds the first edit of the sequence. The edit emphasises the character Lennie's disruption of George's space with a shift in viewer distance and angle. In the next two shots the characters are both represented, but compositionally it is Lennie who is visually foregrounded who dominates the space of the screen (Transcript 4.1 image (c) and (d)). Lennie is represented as 'breaking' the spatial framing/boundaries of the screen. Lennie is represented as disruptive through his movement in this compositional space. The stillness of George and his boundaried spatial framing add to the multimodal construction of his character as 'stable'.

Writing to Speech

Speech and voice-quality are modal resources that contribute to the multimodal transformation of character. The voice of the character George is represented as slow, and clear - each word is distinct and boundaried - and he speaks in a level tone. His voice is relaxed, smooth, full, and unwavering. In contrast, the voice of Lennie is quick, and stuttering. As he speaks his voice is breathless, his words are shortened, the words run together and become mixed-up. He talks loudly, and the words 'shake' as they stumble out of his mouth. This re-presentation of the characters - through voice quality is the result of choices from a range of aural possibilities, choices that carry meaning. The slow rhythm, normative level, and evenness of George's voice quality combine to form a sign of calmness and stability. The fast and faltering quality of Lennie's voice quality signals the meaning of instability and lack of control: the exaggerated stutter serves to remove any sense of clarity. This use of voice emphasises the contrast between the two characters, and marks Lennie's lack of control and his potentially dangerous nature from the start. It provides a less sympathetic view of Lennie and places the relationship of the characters Lennie and George in the context of control and power rather than of friendship.

'What is said' by the characters in the novel is also transformed in the move from page to screen. Those words spoken by George which come from 'slang' are

omitted, such as, 'work up a stake', 'blow their stake', 'poundin' their tail', and 'blowin' in our jack'. George's forms of expression are softened, 'for all anyone gives a damn', for example, is changed to, 'for all anyone cares'. All the references to money in George's speech are also removed. The character Lennie's lack of confidence is omitted, for example, "Go on now, George! No, you. I forget some a' the things" in the original novel is omitted in the 'Novel as CD-ROM'.

These transformations of the dialogue have a number of consequences for subsequent readings of the 'Novel as CD-ROM'. First, the position of ranch workers is individualised. Their failure to settle in a community is decontextualised from the social and historical context of the story. Loneliness, rather than poverty and the need to move to find work, is the cause of failure. The role of money in the inability of workers to realise their dreams is removed, and instead this is associated solely with their having nothing to look forward to. Second, the re-presentation of the characters Lennie and George's plans for their future as 'a little house and a couple of acres' contrasts with their more elaborate plans in the original dialogue of the novel. These plans included a house and keeping pigs, cows, chickens, rabbits, and a vegetable patch. This change serves to suggest that their hopes are in the realm of an achievable reality, rather than a dream or hope which sustains them in their current existence. And finally the dialogue is adapted to appeal to a contemporary audience in an educational context.

The changes in dialogue are not a consequence of change in the medium in and of itself: classic books are often reproduced for children with such changes, such as the Dickens for Children series. What is interesting, however, is that while the dialogue in the video clip is changed the original novel is reproduced faithfully in the written mode in the 'Novel as CD-ROM'. It appears that it is fine to *read* 'gives a damn' but it is not to *hear* 'gives a damn' spoken on the video clip. In addition to the need to make writing 'authentic' as compared with spoken dialogue these transformations are evidence of the designers' perception of the greater intensity of the mode of speech

than writing. In short, the shift from writing to speech changes the strength of the meaning.

The Use of Video in the 'Novel as CD-ROM'

The video clips placed at the beginning of each of the six chapters in the 'Novel as CD-ROM' serve as a multimodal summary of the pivotal events in gradual demise of the character Lennie, who appears in each of the six video clips. Video clip one shows the characters George and Lennie camping out by the river on their journey to the ranch. Video clip two shows George and Lennie meeting the boss of the ranch in his office. George and Lennie are shown in the ranch bunkhouse telling another ranch worker, Candy, of their plans for the future in video clip three. The fourth video clip shows Lennie and Crooks in the barn with some newly born puppies (which Lennie later kills by accident). The fifth video clip shows Lennie stroking Curly's wife's hair (shortly before he kills her by accident). The final video clip shows the characters Lennie and George at the river after Lennie has killed Curly's Wife.

Through the visual arrangement of a range of modal resources (movement, posture, gesture, editing, screen composition, etc), location, character, and narrative episode are used to emphasise the theme of loneliness. The video clips reorder the narrative of the story, placing certain moments at the start of a chapter. In this way, the move from page to screen is used to change the sequence and the pace of the narrative. One outcome of the changed organisation of the 'Novel as CD ROM' is to reposition the characters, in particular Curly's Wife and Crooks, both of whom appear in the video clips. Both the characters of Curly's wife and of Crooks are 'outsiders' within the written narrative of the novel as book and in the original novel there is little description or insight into either character.

Not all of the characters in the 'Novel as CD-ROM' are represented in the video clips. Perhaps most notably, the characters Slim and Curly are not represented in the medium of video: they are literally given no voice or visual appearance. The decision

to represent a character multimodally (in the form of a video clip) gives the character more ‘potential to mean’ than the decision to represent a character in still image and written text alone. That is, ‘giving’ a character a direct voice, movement, and visual appearance realises the entity differently. The characters Curly’s Wife and Crooks therefore become foregrounded in the ‘novel as CD ROM’.

The video clips foreground Lennie, who appears in all six video clips. The visual appearance of the character Lennie is heightened by his propensity for silence – it is others who talk – with the exception of when he is shown alone with George. This modal difference is carried across to other parts of the CD-ROM. Within the Dossier part of the CD-ROM, for instance, only the file on the character Lennie includes video clips in which others talk about the characterisation of Lennie. Overall, the video clips provide a multimodal filter for the construction of the characters in the ‘Novel as CD ROM’.

Written Text to Visual Text

As the video clip described above ends, the screen fades to black, and a new screen appears. This screen shows a line drawing of a country road with an accompanying white block containing writing (occupying 10 % of the screen). Chapter One includes 39 screens, each screen consists of a block of writing ‘over’ a drawing. The introduction of drawings to the text brings forth a range of resources for the realisation of the entity character (including frame, distance, angle, and composition) which are discussed below.

Represented Elements

The characters Lennie and George appear in screen three. The images of the characters are narrative representations; that is, they present them as actors in a series of unfolding events. In the screens of Chapter One of the ‘Novel as CD-ROM’ George is primarily represented as engaged in an activity (walking and looking) with a goal (transactional action). Often these images show George as the actor and Lennie

as the goal of his action. In contrast, Lennie is represented as engaged in non-transitive actions: he looks out of the screen frame and has no visible goal, and we are left to imagine what, if anything, he is looking at in nearly a quarter of screens (8/39). The contrast between these visual representations of the characters signals George as active and Lennie as passive.

Framing

The framing of an image indicates discontinuity or continuity between elements, and what it is that separates or links the elements. Framing allows elements of a composition either to be given separate identities, or represented as belonging together. In other words, framing 'connects' or 'disconnects' elements. The framing of the images in Chapter One of the 'Novel as CD-ROM' is a visual sign of the closeness and status of the relationship between George and Lennie. Framing is used to connect and/or disconnect the characters from one another, and, in this case to suggest the 'disconnected' nature of Lennie. The two characters are represented together in over two-thirds of the screens (28/39) and often they are represented touching one another. Frame as a meaning-making resource is used to represent the friendship between George and Lennie, their togetherness, the disintegration of their friendship, and its recovery. George and Lennie are represented as close together (in the first 11 screens). George is then represented alone (two screens). There is a short moment of being together again (two screens), and the character Lennie is alone again (two screens); this is followed by a moment of being together (two screens), and then Lennie is again alone (one screen). This is followed by a series of screens in which they are shown together but are framed as apart (six screens). Finally the distance between them is removed and they are framed together in a sequence of close-up images (7 screens). As a resource, frame is used here to display a visual rhythm of the characters' interaction. In this way frame realises both the intense character of their friendship, and its volatile nature.

Overall George is rarely represented on his own (2/39). The ‘disconnected nature’ of Lennie’s character is also realised by the use of framing. The character is represented as being alone in nearly a quarter of the screens (9/39). This draws on contemporary visual representations of the lone male as stalker, rather than the empathetic loneliness of the original novel.

Social Distance

As discussed earlier, social distance can be visually encoded to suggest the designers’ desired relationship between viewer and the represented participants. In the images of Chapter One mid and long shots are used to represent the characters George and Lennie walking or Lennie standing looking out of screen. Close-up images are employed in four instances in Chapter One: Lennie drinking from the river; Lennie looking frightened in the dark; George holding his head in his hands; George and Lennie talking. Overall, the character George is more frequently shown in close up than the character Lennie, while Lennie is most frequently shown in mid-long to long shot. Throughout the chapter close up images of the characters are used to visually emphasise the intense emotions that are key to the characters and to their relationship: Lennie’s lack of control and fear and potential physical strength, George’s frustration and guilt.

Attitude

The horizontal angle between the represented participants and the viewer encoded in the images of Chapter One indicates the suggested level of involvement between them. Through the use of oblique angle and mid to long distance shots in the still images, the viewer is placed at a greater distance and more obliquely to Lennie. The viewer is positioned to observe rather than engage with his actions and emotions. In some screens an extreme oblique angle and long distance shot are used to visually represent Lennie as a ‘potential danger’.

Setting

The settings of the story depicted in the images in Chapter One include the open road, the employment agency, the Gabilan Mountains, and the Salinas River. Setting is a resource that is used as a sign of safety and danger throughout the novel. There is a stark contrast between the light and open space of the outdoors, and the dark and confined- space of the in-doors. The actions of the characters and settings throughout the novel on the CD-ROM create a visual link between ‘nature and safety’ and ‘danger and man-made environments’. When the characters are shown outdoors in ‘natural’ settings (which might be read as an absence of ‘society’) they are represented as being safe. When they are re-presented inside, they are represented as being either in danger or ‘in potential danger’. In this way, the setting is used as a visual metaphor to emphasise the threat of society and the comfort of nature (embodied in George and Lennie’s ‘dream’ of living alone together in a rural setting and tending nature). While setting is used as a written metaphor in the novel, the visual mode foregrounds this theme in the ‘Novel as CD-ROM’.

In addition to the images of the settings in each screen of the ‘Novel as CD-ROM’, the written text includes hyperlinks to a map of the (geographical) area in which the novel is set. Locations named in the writing are circled in red, these words link to a map of the area at the time the novel was written. In this way, the narrative is a setting represented as having an everyday reality, and in an image of ‘real’ landscape of the past. This locates the setting more in the realm of ‘the actional’, in the realm of ‘fact’ rather than ‘fiction’.

The Compositional Relationship between Image and Writing

The amount of screen-space occupied by image and writing on each of the screens varies throughout the chapter. Expressed as a ratio, the ratio of image to writing varies the between 5:1 and 3:2. Image dominates the screen-space in the majority of the screens: more than half of the screen-space is occupied by image in over three-quarters of the screens (Table 4.1).

	Less than 50 % of screen allocated to image	50 to 69 % of screen allocated to image	70 % and over of screen allocated to image
Number of screens	6	13	20

Table 4.1: Percent of screen allocated to image by the number of screens

Writing on the CD-ROM, as it appears on screen, is displayed in a white rectangular block, the edges of which are roughly drawn. It has been argued that the visual elements of the screen in CD-ROM versions of books distract students and that visual and written elements should be separated (Graham, 1996). In contrast, this analysis shows that the spatial relationship between image and writing as they appear on the screens of the 'Visual' version of the 'Novel as CD-ROM' is itself a visual meaning making resource. At the level of the screen as a visual entity, writing serves as a visual element and in the first instance makes meaning at that level. In other words, writing serves as a visual element, a block of 'space' which makes textual meaning beyond it's content. The move from page to screen brings with it a shift from the organisational rules of the page to the organisational rules of the screen.ⁱ When writing is present in the multimodal environment of new technologies its visibility is foregrounded. This is a part of the wider tendency in which the use of the visual is expanding. Indeed, written elements on screen are now considered by some to be merely what cannot be done in images (Boulter, 1999). New technologies offer the potential to 'recast modes' in ways which blur the boundaries between the visual and the written. This shift to the visual is apparent in the 'Novel as CD-ROM'.

The blocks of writing are positioned on the screen in different places: the left or right side, along the bottom or top length of the screen, or in the top or bottom corner. Depending both on the size and position of the block of writing different parts of the image layered 'beneath it' are revealed or concealed. The position of a block of

writing (and its movement across screens) emphasises different aspects of the image on the screen. A block of writing may be placed above the head of a character to indicate who is thinking, or along side them to indicate talking, or along the bottom of the screen to visually unite the characters and visually indicate dialogue.

At times a block of writing changes the screen image fundamentally. For example, in some of the CD-ROM screens the block of writing serves to conceal a character, to emphasise a particular part of the character's body, or to hide the object of an actor's gaze (changing their gaze from a transactional reaction to a non-transactional one).

The interaction between the visual and the written element on screen in the 'Novel as CD-ROM' is also used to emphasise the actor, and visually marks the intensity of a moment - through persistence on screen. At times, for instance, an image is arranged on screen to create a visual mood (interpersonal meaning) and rhythm (textual meaning). The image of George and Lennie shown in figure 4.4, for example, persists across three screens, in each one the position of the block of writing differs. In the first screen, the block of writing sits above George's head as he talks to Lennie about what he could do if he left him. In this way the block of writing is visually positioned to represent the thoughts of George. In the second screen the character Lennie is visually obliterated by the block of writing containing George's angry talk of leaving: visually this serves to foreground George. In the third screen, as George's anger subsides, the block of writing is placed on the screen in a position that makes both George and Lennie visible. That is, the block of writing visually 'unites' the two characters. The writing focuses on the thoughts, worries, and dreams of George. The images carry the 'emotion' of a moment while the writing carries an explanation for the response. The image and writing 'attend to' separate aspects of the narrative. Mode is used to emphasise George's isolation and lack of power. At times image and writing appear to 'belong' to the two characters differently: Lennie is more frequently represented as expressing himself visually and George more often through writing.

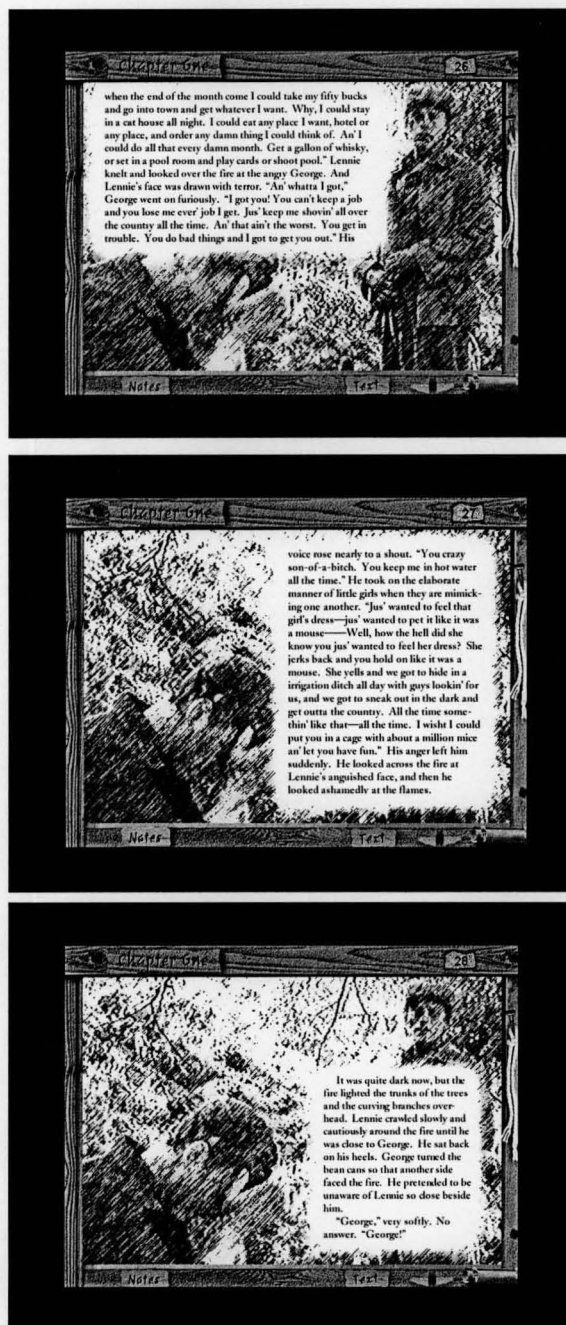


Figure 4.4 The relation of image and writing over three screens in the 'Novel as CD-ROM'

The images are not illustrations to the writing; they realise a number of ‘unsaid’ meanings as a visual summary of the ‘Novel as CD-ROM’. Including the volatile and changing nature of the relationship between the characters George and Lennie, and the potential sexual threat of Lennie and his ‘disconnected’ nature. The designers’ desire for audience empathy and identification with George and for the objectification of Lennie is realised visually. In addition the connection between nature and safety, and man-made society and danger is visually made.

The Character Guide

The ‘Novel as CD-ROM’ includes a video character guide named Bindy. This guide appears at 15 different points throughout the novel, including three times in Chapter One. As the reader moves through the ‘Novel as CD-ROM’, the guide automatically appears in the bottom right hand corner of the screen. He provides a spoken commentary on different aspects of the novel. This includes the theme of the novel (identified as loneliness), social historical information on the time of the novel, the production of the novel as a play and films, Steinbeck’s life, influences and the inspiration for the novel, and the effect of the novel on Steinbeck’s career.

The visual appearance of the character guide Bindy (figure 4.5), particularly his clothes, voice and style of speaking are similar to the appearance, voice and style in the re-presentation of the character George. Like George he is shown wearing dark jeans, a check brown shirt, and a brown rimmed hat. Visually, Bindy’s clothes and physical stature present him as an echo of George. In his third appearance in Chapter One Bindy is shown shuffling a deck of cards, an activity associated with George throughout the book as a symbol of his loneliness and ‘patience’ which is also visually referenced and discussed in his dossier file (discussed later in this chapter). In this way, George’s perspective is foregrounded through the embodiment of ‘parallel’ features in the character Guide Bindy.



a. Sequence 1

b. Sequence 2

c. Sequence 3

Figure 4.5 The opening screen of the three sequences of Bindy in Chapter One.

In the first sequence (shown in figure 4.5 a) he is shown as *emerging* from an image of the setting of the 'Novel as CD-ROM'. He stands with his hand on one hip, a relaxed but controlled posture, and says in a rich, country voice:

If anything Of Mice and Men is about intense loneliness and anger brought on by hopelessness. It is not surprising then that John Steinbeck set his novel a few miles south of Soledad, California. Soledad is Spanish for solitude.

The image of the character guide then dissolves and shrinks 'back' into the screen.

In the second sequence (figure 4.5 b) Bindy is initially shown *outside of* the 'Novel'. He walks into view from outside of the frame, and jumps up, trying to reach the 'rope' hanging on a nail on the right hand frame of the screen. Failing to get the rope he instructs the user, 'Well anyway, if you wanta' make a bookmark, click here' and then 'exits' walking 'off screen'

In the third sequence (figure 4.5 c) the character guide walks in to screen from the side-frame of the screen image. He steps one foot over the edge of the frame, sits

down on the frame, and starts to shuffle a deck of cards. He looks directly at the viewer as he says:

Throughout his career Steinbeck experimented with different sorts of writing, in May of 1936 right in the middle of *Of Mice and Men* he gave the reason for writing what he called a play and novel form. 'I think the novel is painfully dead' he said, 'I 'm going into writing for the theatre which seems to be warming up'. *Of Mice and Men* was a big hit on Broadway.

As a guide Bindy is shown both as inhabiting the world he can guide us through the world of the characters George and Lennie depicted in the novel, and the world of the viewer, outside the novel, and he can straddle the divide between the two.

In each of the sequences the guide addresses the viewer directly. His lexis and syntax like his dress is informal, and he speaks directly to the audience. In each sequence he makes direct eye contact with the imagined viewer. In each sequence he has a frontal body posture (he turns around in the second sequence (figure 4.6 b after trying to get the rope) and his arms and hands are on 'show', his face turned to the imagined viewer. Bindy, like the character George, speaks in a measured even tone, not an emotional one, and with a strong 'country' accent, and his voice has a steady quality.

The character guide Bindy, his appearance, open body posture, and country 'twang' are modal resources used to represent him as honest, and perhaps more importantly as 'authentically' lower-working class person. The guide is placed in the role of storyteller and through a narrative style he presents a range of information. The narrative interludes provided by Bindy offer the reader of the 'Novel as CD-ROM' an alternative view of the text. The guide introduces the need for the reader to move *beyond* the text, to understand the author, the social context of the novel as well as the need to move *through* the text to get at its meaning, its themes, and how it extends other texts. He 'suggests' practices to the reader, to bookmark the text as they read, to make notes, and so on. In this way the character guide Bindy structures and

presents the content of the 'Novel as CD-ROM' for the reader (Oren et al., 1990). The sequences of the guide also serve to break up the text, to literally stop the reader and 'make them think' beyond the text, about what the author is trying to do, or the author's motivation for setting the story where it is, for example. These sequences 'model' the work of analysing a text: the character guide, like the characters in the 'Novel as CD-ROM', is meant to make the reader think and act.

Student Interaction with the 'Novel as CD-ROM'

This section focuses on how some students interacted with these resources, and describes their 'reading' of the 'Novel as CD-ROM' as a visual text. In the novel the entity character is realised through the written mode. The 'Novel as CD-ROM' represents character multimodally. A character's voice is heard, bringing voice into play as a mode and with it a set of semiotic resources for meaning making - voice quality, rhythm, tenor, pitch, and so on (van Leeuwen, 1999). A range of actional modes are also made available visually via video, including facial expression, posture, gesture, movement, and clothes. These visual and aural resources shape the re-presentation of character. These potentials are selected, and 'designed' (configured and arranged on screen) into texts which shape (re-present) the entity 'character' in specific ways. Multimodal texts such as these provide new resources for students to engage with in the their construction of character (Goodwyn, 2000).

It has been suggested that CD-ROMs enable learners to determine their own route through materials (Andrews, 2000), and that reading from screen offers a less alienating experience of a text (O'Donoghue, 2000). This multimodal analysis shows that interaction with the 'Novel as CD-ROM' in this instance extends the notion of reading.

The 'Novel as CD-ROM' 'read' as Video

Here I give an account of two students', Justin and Ben, engagement with the 'Novel as CD-ROM'. Justin and Ben 'open' it, and quickly close the first video clip (as the

first video clip opens automatically when the 'Novel as CD-ROM' is selected they have seen the scene many times). Ben has memorised the rough location of the video clips via the 'page numbers' displayed in the top right corner of the screen. He and Justin use this information to find the first video clip that they watch. Ben types in the page number on the computer keyboard and instructs Justin to move backwards or forwards using the icons on screen until the video clip is found and opened. He has memorised the elements in sequence (what goes before and what comes after) to locate the video clips: he has internalised the structure of the visual narrative. Having located the video clips the two students sit back, hands off the mouse and keyboard and watch the video. Later they realise that the video clips are always at the start of a chapter and they switch to using the Chapter Menu Bar to find them.

The use of the Chapter Menu Bar as a navigational tool enabled the two students to move almost seamlessly through the 'Novel as CD-ROM' as a series of video clips. The students by-pass the novel as a written text (i.e. they do not engage with it) and instead engage with it as a (multimodal) video.

The 'Novel as CD-ROM' 'read' as Comic

Two students, Natasha and Holly, first watch the video clip described earlier. As the video clip closes the screen of the first page in the 'Novel as CD-ROM' automatically opened. Holly instructs Natasha to "keep going along", and she clicks the forward icon with the mouse. As the character guide Bindy appears she clicks to move on, but cannot. The two students watch the screen and Natasha holds the mouse. As Bindy closes, Natasha clicks the forward icon every two or three seconds and moves through the next 12 screens in this way. Both students lean forward to the screen and look directly and intently at it. The next clip of Bindy opens, the students watch him, and then Natasha clicks the forward icon to move through the next nine screens of the 'Novel as CD-ROM'. As the next Bindy clip opens, Natasha appears to try to close it, and failing that, to try and leave the 'Novel as CD-ROM', Holly instructs her to stay in the 'Novel as CD-ROM' area and to "keep going". Natasha clicks on the forward

icon every 2 seconds and moves through the next 14 screens. The second video clip, in which the characters Lennie and George meet the boss of the ranch opens. Natasha takes her hand off the mouse and both students lean back in their seats and watch the video clip.

The students did not flick casually through the screens, talking, or looking elsewhere. Their flicking was accompanied by intent looking, an intense engagement. The students' movement through the screens in this way is a form of engagement with the novel at visual level.

The potential for animation is enabled by the origin of the images on screen – the still frames from a film. This enables a coherent text to be produced through the encoded conventions of film. The students' 'flicking' movement through the still images of the chapter 'animates' the text like a cartoon. The two students then watch the film clips. This offers the two students 'watching' the novel as a visual text, different potentials to make meaning with. As discussed earlier in this chapter, the elements on screen, their compositional relationships, the use of representational angle, distance, and frame, etc. combine on screen to provide a visual summary of the chapter. The images display the sequential events of the novel: walking on the road, thirst – have to drink from the river, going into town to an employment agency, walking again, resting, meeting noone, tiredness, nightfall, sitting together around a fire, talking, camping by a river. Engaging with the novel as a visual text offers a visual summary of the themes of the novel: loneliness, hardship (e.g. sleeping outside, walk most of day, no food, only river water to drink), and friendship. The key features of the characters are realised visually, the images display the changing relations between the characters, and emphasise particular emotions, and realise viewer relationships to the characters.

In this way the students' form of interaction with the text served to reshape the entity character by shifting the 'high' literacy aesthetic of 'novel' to the popular textual genre of comic and film.

The Multimodal Reshaping of Character in the Dossier Section of the CD-ROM

The Dossier part of the CD-ROM provides a 'file' on each of the characters of the novel and it draws on a range of modes. The dossier menu provides a list of names displayed as a 'work roster for august 30' (figure 4.6).

Typography

The majority of the characters' names are written in a font similar to that of an old typewriter and are circled in red. The characters 'the boss' and 'curly's wife' are 'hand-written' in red ink. The characters with typed names are in the genre of a list and are allocated a role. Through the contrast of font-style, colour, and spatial layout, the boss, and curly's wife are presented as outsiders. The use of font, colour, and the comment 'botherin us' in the name of the character Curly's wife positions her as an intruder.

The menu includes five names that are not mentioned in the novel: Frank Caster, Richard Spitz, Felix Saltillo, Julio Vasquez, and Jack Dupac. These names are not circled and do not link to a file. The names signify 'ethnic diversity', a social historical detail about the labour force that is not present in the original novel. The names serve to address a contemporary readership, but in a most superficial way, as literally this is not taken further.

The written descriptions of characters in each dossier file draw directly on the novel. These are presented in a 'hand-written' font in the form of a reference from the employment agency and are 'signed' (see figure 4.6). Written texts in the dossiers,

beyond the immediate level of display, that is that are linked to the opening screen of the dossier, are presented in a plainer font, and have scroll bars (see figure 4.7). In the former case the 'hand-writing' font is used to visually mark the presence of a human writer. In this way the content of what is written is visually expressed as a personal and potentially 'fictional' account. In the later case, the plain font does not foreground the author of the letter or the personal character of a letter. This use of font, together with the use of scroll bars, serves to position the content of the writing as a formal and factual account. The contrast in the use of framing and typography between these two screens indicates the different kinds of work the student is being asked to engage with. In the first case, the work of imaginative engagement, and in the second, the work of engagement with the historical 'fact'.

Images

The opening menu (see figure 4.8) shows the manila files of the dossier files lying on an embossed blotting board. Through these visual props the reader of the Dossier is placed in the viewing position of 'the boss'. That is, the reader is visually repositioned to the text, or perhaps more accurately 'into the text'. Each dossier contains a close-up photograph of the actor(s) who played each character in the 1992 MGM film version of the novel. This visually places all of the characters within a shared contemporary time frame and genre.



Figure 4.6 Curly's Wife's dossier file an example of the screen of a character dossier file

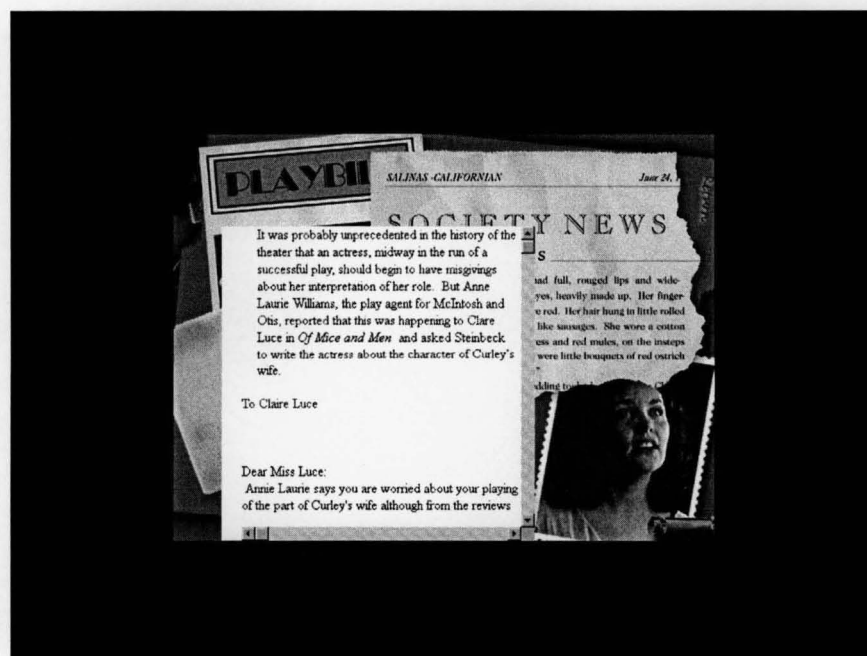


Figure 4.7: Curly's Wife's dossier file an example of a link screen

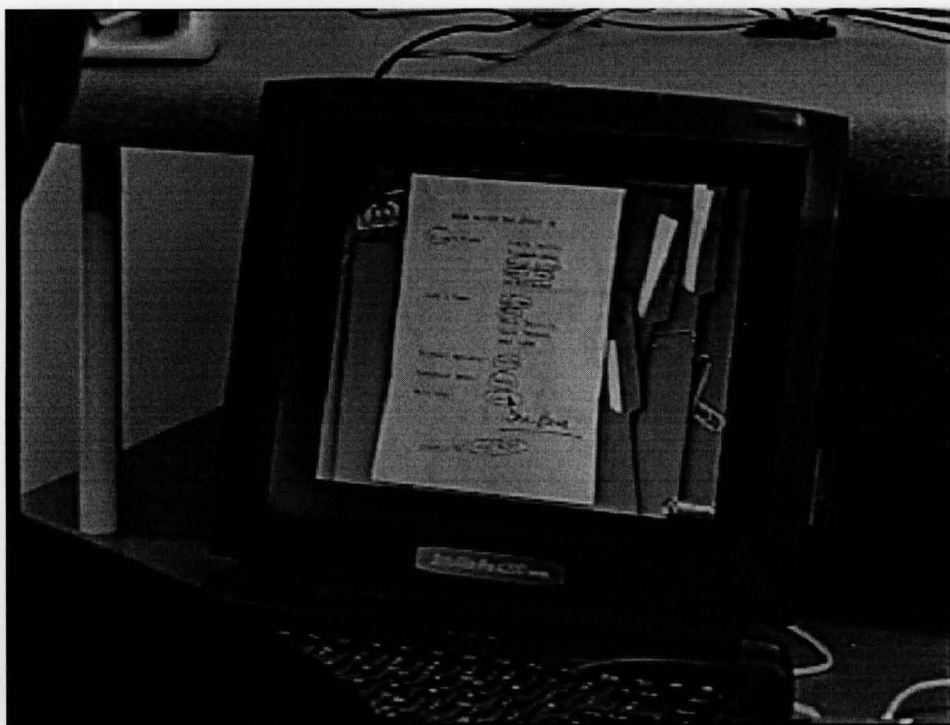


Figure 4.8 The Dossier Menu Screen

When a photograph is selected with the mouse, a written caption appears with the name of the actor, and the year and venue of the production. In some dossiers two or more photographs are displayed. This visually highlights the relationship between the characters and the actors who have played them, and asserts the potential for a character to be re-presented in different ways. The images provide the viewer with alternatives to

their potential visualisation of the character, and opens up new potentials for contrasting, and thinking of character beyond one realisation.

The objects that are included in each of the dossier files contribute to the construction of the characters and serve to emphasise key themes, and connections. In the dossier file of the character Curly's Wife, for example, the images of envelopes addressed to her (see figure 4.6) means that the character is literate, and that she is in contact with, and cared for by someone (as I suggest later, perhaps the character George). The theatre ticket visually references the character's social desires and links the actor Clair Luce and the character she plays and the author Stienbeck – who the letter in her file is from.

The character Crooks is visually repositioned via the Dossier. A photograph in the character dossier shows the character Crooks cleanly dressed, standing in a tidy room, looking out at the viewer with an intense gaze. The image shows his possessions neatly organised, including a collection of books and a light – visual symbols of intelligence. The visual presentation of Crooks within the same frame as the other characters in the Dossier serves to equalise him and the others characters.

Voice

All of the characters are represented visually in photographs and in the mode of writing within the dossier files. They are also represented by the narrator's reading of the written description of the character in the files. The voice of the narrator is male, deep and even toned. The fullness and deep tone of the narrator's voice is intensified,

and the pace significantly slowed, when the narrator reads the description of Crooks. His voice is deep, full, and 'church-like'. He reads the description of Crooks in a slow voice indicative of gravity and respect. Through the use of image and voice, the character Crooks is removed from the racist animalistic textual context of 'nigger' and 'stable-buck' of the original novel.

While all of the character files include a spoken description of them, not all characters are given their own 'voice' in the dossier files. The dossier files of the characters George, Lennie, and Curly's wife include audio clips. The characters George and Curly's wife sing about their feelings. The words of the two songs, the character's voice quality, rhythm, tone, pitch, and pitch range and music focus on the emotions and private thoughts of the character, and tell of their dreams and hopes. Each character speaks directly to the viewer/audience in these songs. George's voice is strong but mournful, a steady bass tone. First accompanied by a 'clinky' music hall style piano, and later a strong bass and saxophone blues rhythm. Curly's wife sings in a deep pleading tone, accompanied by a similar style piano.

George sings mournfully:

A guy sick of the life he has known
He hopes some day to meet a girl
A girl who will be his own
A girl, a girl

Almost as if in response Curly's wife sings:

I got a man who ain't never home
Got no one to be with me
I got no women folk livin' near by
I'm too much a lone

Just someone to talk to
Nothing more, nothing less
Any little words at all
Take away the loneliness

Across the two dossier files the deep mournful tone of both their voices, the words they sing, and the style of the music is suggestive of a duet between George and Curly's wife.

Interestingly the character Lennie's voice is limited to a request - he asks George to sing to him, which he does. The character George literally 'speaks for' the character Lennie. The dossier on the character Lennie contains two further audio clips in the form of commentary about the character Lennie, one from an academic, and the other from Steinbeck's partner. In other words the character Lennie is talked about more than 'he' talks.

Range of Modes and Links

The range of modes, the number of links to other screens, and the number of visual objects (photograph, visual objects, written text) in each character dossier file varies. These factors, mode, link, and visual objects are a visual indicator of the importance of a character.

The widest range of modes (voice, image, and writing) is used to display the information in the dossiers of the characters Curly's wife, Lennie, and George. The modes, visual objects and links of these three characters are shown in comparison with the Curly in Table 4.2.

The dossiers of the characters Curly's wife, Lennie, and George include more than twice as many visual objects on screen as the other character dossiers. The visual objects represent aspects of each character, as discussed earlier. Through these

multimodal resources the three characters, George, Curly's Wife, and Lennie, are represented as equally important. The character Curly's wife is modally repositioned from a marginal to a central character. In addition, the dossier reshapes her character by visualising her vulnerability (in a series of photographs) and the telling of her perspective on life via the mode of voice and song. The visual objects displayed in the character files also realise relationships between the characters, as discussed in the next section.

Table 4.2 Comparison of the modes and links in the dossier files of the characters Curly's wife, Lennie, George, and Curly¹.

Character dossier file	Modes of representation	Number of visual objects	Number of links
Curly	Image and writing	2	-
Curly's Wife	Image, writing and voice	5	3
George	Image, writing and voice	5	3
Lennie	Image, writing, and voice	5	3

The Sharing of Objects, Visual and Audio Links

The visual sharing of objects and links across character files enables students to pursue textual and thematic issues (Goodwyn, 2000). In this CD-ROM shared objects appear to be a visual indication of a relationship between characters. Meaning is constructed from the juxtaposition of different texts, and events which unfold 'through reading across and among various media' (Zancanella et al., 2000: 99). Four of the character files contain shared visual objects.

¹ The dossier file of the character Curly is typical of the other character dossier files in the CD-ROM.

The files of the characters Curly, and Curly's wife share the image of a newspaper cutting. The characters George and Lennie share the image of a play poster. The characters George and Curly's wife share the image of an envelope. Through the use of a shared image of a hand-addressed envelope in the files of the characters George and Curly's wife the Dossier visually introduces the suggestion of a relationship between them. The addressed envelope is suggestive of a romantic, secretive relationship. The link between the two characters is also realised by the use of audio clips in the character Dossiers. Through the visual and aural re-shaping of character the potential for a relationship between George and Curly's wife is presented in the CD-ROM. This introduces a heterosexual romantic strand into the narrative that serves to realise the vulnerable femininity of Curly's Wife and the heterosexuality of the character George. It also suggests a glimmer of hope (and escapism) to the 'Novel as CD-ROM' that stands in stark contrast to the bleak and relentless loneliness and realism of the original novel.

The modal transformation from page to screen does not demand these shifts in the centrality or re-presentation of characters; rather it makes it possible to reshape the characters and their relations, at the same time as maintaining the original novel as a text. The reshaping of the novel occurs in the designer's use of visual and aural modes, while the mode of writing is used to maintain (reproduce) the text of the original novel. The multimodal reshaping of the characters Curly's wife and Crooks repositions the novel for a contemporary audience. The potential to read the novel as sexist and racist (a view expressed by some of the students on reading the novel) is visually 'overlaid'.

Students' Multimodal 'Readings' of the Dossier

The students reading of the novel and the CD-ROM are, in the context of the English classroom, infused with the histories of English as a school subject, the demands of the National Curriculum, and the desire for students to identify with characters.

Having read the Novel, *Of Mice and Men*, but prior to using the CD-ROM, the majority of the students chose the characters George or Lennie as the focus for their course work ‘a day in the life of’. After using the CD-ROM the students chose a broader range of characters for their course work including, the Boss, Crooks, Slim, Curly, Curly’s wife, George and Lennie.

When exploring the CD-ROM Dossier, one student, Dave, repeatedly selected and viewed the file of Crooks. He spontaneously commented on Crook’s character file as his ‘favourite bit’ several times. Dave changed his choice of character for the course work from Lennie to Crooks. When asked why by the teacher he said it was because he was the only Black character and that the CD-ROM had given him more information about the character (transcript 4.2):

Transcript 4.2: Excerpt from the discussion in the classroom after using the CD-ROM

Dave: I changed my character to Crooks, cos he’s like the only Black man there and he’s very lonely.

Teacher: you knew Crooks was the only Black man in the novel when we read it, so what made you change your mind after looking at Crooks on the CD-ROM then?

Dave: the dossier give me more information about him, because the book don’t really talk about him, it, as being a shy man, and um the description of his room as a ...Dung Heap.

The Dossier files represent each character ‘decontextualised’ from the original novel. While on the one hand it can be problematic to separate character from narrative, on the other hand it provides a new opportunity for students to engage with the novel and with the characters. The multimodal re-presentation of the character Crooks in the Dossier and in the video clips included in the ‘Novel as CD-ROM’ re-present him as a person removed the character from the racist animal-like context of ‘nigger’ and ‘stable Buck’. The re-shaping of this character provided Dave, a young Black man, with a new potential to identify with the character. That is, the resources of the

Dossier served to provide a visual multimodal filter with which to engage with the characters within the context of the novel.

Several students' interaction with the Dossier section of the CD-ROM was mediated by the combination of image, music and song. These students selected the character files with visual links to songs. Just as Justin and Ben 'watched' the 'novel as film', and Natasha and Holly 'read' the 'novel as comic', these students engaged with the 'novel as musical'. Song and music was a central feature of several students' engagement with the character Curly's wife. During one 50 minute lesson, for example, two students, Kate and Carol returned to Curly's Wife's song on three occasions, learnt some of the words, and quietly sang along to the chorus.

Kate, and Carol decided after using the CD-ROM to focus on the character Curly's wife in their course work. The song sang by the character was given by them as the reason for this change (transcript 4.3).

Transcript 4.3: Excerpt from the discussion in the classroom after using the CD-ROM

Kate: I'm doing Curly's wife

Teacher: And that's a change isn't it? You didn't do Curly's wife before?

Kate: No I did Lennie before.

Teacher: So why have you changed?

Kate: I didn't know that she sang.

Teacher: You like the song. And what was it about the song? Because I think you and Carol because both you and Carol have chosen to do Curly's wife, it's a change for both of you. And I think for both of you the song was very significant wasn't it?

[students nod heads]

Teacher: So Carol, what is it about the song?

Carol: I liked listening to it, one reason I liked it is cos when she's singin' its about how she feels, and, and that's what I think.

The song played a central role in these two students' identification with the character. The song literally 'gave voice to' the character Curly's Wife. The character's singing presented them with an insight into her emotional life via her voice. In the process the character was transformed from a hardened vamp into a victim of a sexist society. Through her voice, the music, and the words of the song the character Curly's Wife in the 'Novel as CD-ROM' was drawn into the inclusive theme of loneliness. The 'knowledge' that she sang (rather than the song itself) appeared to be key in the reshaping of the character for the student Carol. Perhaps for this student singing is a metaphor for emotion. As was the case for Kate, the multimodal re-shaping of the character provided these students with a different potential for engagement with the character Curly's Wife.

Multimodality, New Media, and Learning

The resources of page and screen offered students and teacher different possibilities for engaging with specific characters and the construction of character as an entity, and brought forth quite different practices of interaction.

Textual Evidence

The Dossier part of the CD-ROM enabled the students to engage with the entity character independent of the novel itself. In doing so, the CD-ROM offered a model for studying the text for characterisation: the segments of the novel selected as 'textual evidence' explored characterisation as a symbolic device through visual objects and links. Further, the potential to explore the entity character dislocation from the narrative appeared to provide a potential for some students to identify with marginal or negatively portrayed characters. In addition, placing the characters within a shared format of display appeared to have an equalising effect on characters.

Social-historical Context

The structure of the CD-ROM provides a modal commentary on the work of studying character within a set text: the expectation that character be understood in its social-

historical context, and the need (literally) to move beyond the immediate text. That is, the structure of the CD-ROM provides a reflexive tool for the study of character as an entity. The organisational structure of the CD-ROM Dossier and the 'Novel as CD-ROM' (in particular the character guide Bindy) visually model the need to move between studying character at the level of the novel as fiction, placing character (and the novel itself) in a historical context.

In the Dossier the screens which automatically open when a file is selected include a spoken and written description of the character, a photograph of the actor who played them in the 1992 film version of the novel, and in some files a collection of visual objects and hyperlinks. This 'default' screen is a multimodal engagement with the entity character within the 'fictional domain' of the novel. Selecting a visual object link on the screen leads to a domain of 'linguistic' commentary on character as an entity. These linked texts are intertextual references, either in the form of factual texts (such as letters from Steinbeck about a character, the actor who played a character, or an academic writing about the character) or spoken, sung, or written references to the construction of character within productions of the novel. This level can be seen as a 'factual domain' beyond the fictional novel. That is, fiction is constructed via the visual, while fact is constructed via 'language' written, spoken, or sung. In the case of the 'Novel as CD-ROM' visual hyperlinks (and the multimodal character guide 'Bindy') enabled students to move between the entity character in the novel as a text in the 'fictional domain', and the social- historical construction of character in the 'factual domain'.

This structure indicates that two different kinds of engagement with the entity character and the 'Novel as CD-ROM' more generally are required of the student. The first, at the level of display, demands the students' imaginative engagement with character. The second, at the level of language (written, sung or spoken), demands engagement with the social-historical context of the novel and its subsequent 'life' as a text. The ideological expectation in school English that students should move

beyond a text when they engage with it, is embedded in the multimodal orchestration of the CD-ROM, in particular, the relationship between visual, aural and written elements.

Intertextuality

While the 'Novel as CD-ROM' does the 'imaginative work' of constructing the characters it also offers an intertextual construction of the entity character. In addition to the multiple layers of the 'Novel as CD-ROM', the Dossier offers images, artefacts, and audio clips from film and stage productions of the novel. This provides a potentially more complex notion of character. Character is represented not as the product of one person's design/reading rather it is represented as the multimodal outcome of interaction with many voices and modes over time. This represents the entity character as a dynamic entity that emerges from a social rather than an individual production.

Multimodality

The multimodal resources of the CD-ROM demanded that students engage with the entity character at the level of mode (visual appearance, action, and voice) and at the level of narrative. The multimodal transformation of the characters via the resources of the CD-ROM also repositioned the novel to account for the imagined concerns of a contemporary audience in an educational context.

The opening scene of the first video, for example, shows the intimacy of the two characters George and Lennie. In doing so the theme of relationships and friendship is visually foregrounded. The characters George and Lennie are polarised by the contrastive use of appearance, clothes, voice, gesture, composition and editing: any sense of sameness is removed by this multimodal reshaping. Further, through these visual resources the relationship between the two characters is constructed as an adult-child relationship. This reshaping of the characters presents a new set of motivations for character and narrative.

Through the visual arrangement of image and writing on screen in the 'Novel as CD-ROM' the entity character (through resources such as framing, and spatial relations) indicates the intensity of emotion, to suggest viewer identification with George, and to emphasise the agency/passivity of the characters in the novel.

The multimodal resources of the 'Novel as CD-ROM' also serve to emphasise particular characters and moments of the story. First, characters were literally given appearance and voice. Second, they appeared in the repetition of moments in the three different forms video, still image, and writing. The pace and thematic emphasis of the structure of the 'Novel as CD-ROM' is transformed by the placement (and repetition) of what are effectively concluding 'moments' at the start of each chapter via the video clips. These clips serve to immediately foreground the entity character rather than other aspects of the narrative in a way that shifts the focus of reading the text from the social to the individual. Further, the use of visual links and objects in the Dossier part of the CD-ROM also served to re-position, make central, the marginal character Curly's Wife.

Practices of Learners

The work of the students was to interpret this multimodal representation of character. 'Reading' or perhaps more aptly 'watching' the 'Novel as CD-ROM' introduced new resources and practices for constructing and understanding the entity character. The multimodal organisation of the 'Novel as CD-ROM' offered students a range of modes with which to engage with it including, video, image, or image and writing. This enabled the students to engage with character and narrative at different levels of reading. The video clips provide a multimodal construction of character and the realisation of the themes friendship and loneliness. These are atomised from the context of the novel and centred on affect and emotion. The screen images throughout the 'Novel as CD-ROM' enabled a deeper exploration of character in the context of the sequential unfolding of the events, changing relationships, and

locations. Finally, the written text realises character through the narrative descriptions of the novel. In the 'Novel as CD-ROM' choice of mode is a choice of the level (detail) of engagement with the entity character.

These multimodal resources enabled students to 'navigate' the entity character modally in different ways via song, image, written description, or via the video clips. Several students for example engaged with the entity character entirely via song. This temporarily transformed the 'Novel as CD-ROM' into a musical performance/sound track. Several students 'watched' the 'Novel as CD-ROM' in the form of a film. Others 'read and animated' the images via their movement through the text momentarily overlaying the 'Novel as CD-ROM' with the genre of comic. In short, the resources of screen enabled the students to bring different forms of engagement to their interaction.

Conclusion

Engaging with the book *Of Mice and Men* required the students and teacher work with the mode of writing. They read to imagine the characters, their motivations, emotions, appearance, voice, and so on. The students' identification with the characters and the moral dilemmas they encountered is foregrounded in this reading. The multimodal transformation of the novel *Of Mice and Men* to CD-ROM offers several readings of the novel. It reshapes the characters, their relations and motivations, and the narrative. It 'fills in' the descriptions of the characters: it 'does' much of the imaginative work demanded of the students as they read the book. The electronic reorganisation of original text into the CD-ROM is fragmented, the narrative is reconfigured, and the issues of morality brought about by the careful written webs of connections are ruptured and diffused.

The CD-ROM provides the students with different tools to things to think with in their engagement with the entity 'character' which reflect the demands of the curriculum. The merging of voices in the Dossier of the CD-ROM offers an explicit

notion of character as an entity produced by many people over time rather than the stable authoritative voice of the author. Character is presented not as a stable (moral) emblem but a fluid entity that demands to be read in a social-historical context beyond the text. This suggests that the entity character is not the product of an individual reading but the outcome of a collective social reading.

Even though my primary focus in this chapter has been on the construction of the curriculum entity 'character' what is also very clear is that the practice of reading the 'Novel as CD-ROM' is reshaped in the move from page to screen. Amongst all the uncertainty of what it is to engage in a meaningful way with new media in school English it is clear that the expansion from novel to screen has implications for traditional notions of literacy and learning. The students' engagement with the CD-ROM described in this paper suggests that the forms and practices of reading such multimodal texts remain relatively open for the time being. 'Reading' or perhaps more aptly 'watching' the 'Novel as CD-ROM' introduced new resources and practices for navigating, constructing and understanding the entity character. In this multimodal environment it is clear that to persist in thinking of learning English primarily in terms of writing and speech is problematic. Doing so only serves to highlight 'the cultural chasm between adult and child, with the child clearly seated in a visual world' (Underwood, 1999:110).

ⁱ That the computer-screen has not always been occupied by the visual, in the same way that you can write on a canvas, or paint on a clipboard does not undermine the visual character of the site. 'Old' technologies always occupy new technologies (as witnessed by the running boards on cars, the key boards on computers). The question of whether or not these technologies are best suited to the spaces they occupy is something that can only be resolved over time.

5. Mathematics and the Multimodal Construction of ‘Rule’ and ‘Bounce’ on Screen

Introduction

Toontalk is a computer programming application for children (age four years old and over) to build computer games. Toontalk makes available a range of representational and communicative modes including still image, gesture, gaze, body posture, speech, sound-effect, writing, and new configurations of the elements of these.

In part one of this chapter I ask how the range of representational modes made available in Toontalk shape the potentials for learning. I show that the semiotic potentials made available via a multimodal text, such as Toontalk, contribute to the shaping of what students can ‘do with it’ - how they can ‘design meaning’. In order to understand the rule building practices that students engage with in Toontalk, a better understanding of the kinds of meaning-making resources that the application provides is required. There is a need to understand what it is that students are working with and how these multimodal resources might contribute to the shaping of the learner, the learning environment, and what it is that is to be learnt. The multimodal analysis of the application presented in Part One centre on the impact of modes on the mathematical entities *rule*, *condition* and *action* and the subjectivity of the user.

In the second part of the chapter I explore the role of these representational modes in the process of game design and game construction. Computer based applications are frequently discussed as being effective tools for learning. However, the question remains of how the move from traditional technologies of teaching and learning to computer based technologies actually reshape the practices of learning. The analysis focuses on two students’ construction of a game in Toontalk, in particular programming a bullet to ‘bounce’ and the emergence of ‘bounce’ as a mathematical

concept. Through this analysis I show that the choice of representational modes in the design of the program is central to the potentials for user engagement. Modes (e.g. image and writing) provide the maker of an application and the user of it with different features for making meaning, and in this case, for understanding what is at issue in engaging with aspects of programming and building games.

Using Toontalk and School Mathematics

Numeracy is core to current government education policy. The National Numeracy Strategy was launched in 1998 and has been formally implemented in classrooms since September 1999. The National Curriculum asserts that,

Mathematics equips pupils with a uniquely powerful set of tools to understand and change the world. These tools include logical reasoning, problem-solving skills, and the ability to think in abstract ways. Mathematics is important in everyday life, many forms of employment, science and technology, medicine, the economy, the environment and development, and in public decision-making.
(Dfes, 1999)

Information and communication technologies are seen as central to the teaching and learning of Mathematics in schools. The after school computer club (and the Toontalk Project) that the data discussed in this chapter is drawn from sites outside of the formal classroom environment. However the students' work with Toontalk, and their game making involves concepts and practices that are central to school Maths, the National Curriculum, and the government's Numeracy Strategy. In particular, as the students work together to design and build a game in the computer application Toontalk I show that they are forced to engage with the mathematical concept 'rule', and the relationship between 'condition' and 'action'. The students also work with the concept of 'angle' in order to make a bullet fire and bounce in the way that they want it to, the work of estimating and understanding angles is highlighted in the Numeracy Strategy.

All games can be understood as complex systems of rules. This includes social rules (such as who gets to go first and the rules governing the behaviour of the player) and system rules. Computer games involve the players of a game in negotiating the social rules and in interacting with a formal system of rules. System rules can be understood as ‘a formal expression of object relationships in a programming system, that is a programmed rule that specifies the formal condition and action for the behaviour of game elements’ (Adamson et al., 2002:1). I show that through the process of making a game the students became increasingly aware of the system rules of Toontalk and are forced to consider the relation between condition and action. This process enables the students to learn about rules and how they can be modified and expressed.

As I will show through the analysis offered in this chapter, the process of constructing a game in Toontalk requires the students to engage in problem solving and understanding the mathematical relationships that underpin everyday phenomena such as movement. The students use logical thinking, reasoning and generalising skills, and predictive abilities in order to solve design problems. These are core skills that are emphasised in both the National Curriculum and the Numeracy Strategy.

Part 1: A Multimodal Analysis of Toontalk

Toontalk uses an animated programming paradigm in which animations are the source code of the language. Programming in ToonTalk (which is a Turing equivalent ‘language’) is done by example (see Cypher, 1993, Lieberman, 2001), with animated robots being trained to work on an example input. Set in an animated world consisting of a city with streets and houses, these resources consist of ready-made games, picture and sound media, and pieces of combinable ready-made Toontalk programming code (termed ‘behaviours’ in the Toontalk application). An ‘actor’ can be given functionality through the addition of a ‘Behaviour’. Interacting pictures are then combined to form a game. I show that the games, media and Behaviours in Toontalk facilitate multiple entry points for young children into the

ideas of programming and rule making in order to formalise ideas. (For a detailed discussion of ToonTalk code see Kahn 1996).

Toontalk consists of a game mode and a program mode, each of which I describe and discuss in the next section.

Toontalk Game Mode

‘Game mode’ can be understood as a transformation of the program into ‘output’ in the form of a rule sequence of moving, visual, and aural signs. The game mode in Toontalk is a multimodal organisation of several modes, the modes of colour, movement, sound-effect, and still image. There are three levels within the game mode. First, there is the city level that is automatically displayed when the user enters the Toontalk system. The city is an ever-present ‘game’ that can not be altered, although it is possible to build new houses, to decorate them, and to control the dimensions of the city. The second level of game mode is ready-made games, and the third is the behaviours, each of which is described in turn in the next section.

The City Level

The Toontalk opening sequence is a multimodal metaphor of the ‘city’. The city level is a visual map of the resources of the Toontalk. It is also a game. There are four ‘sub-levels’ within the city: The first sub-level is a representation of the city from above. The second sub-level is a representation of the city at the level of the street. The third sub-level is a representation in the city of the inside of a city house. The fourth sub-level is a representation in the city of the floor of a city house. The multimodal construction of each of these sub-levels of the city level is discussed in this section.

Representation of the City from Above

The image of the opening screen of Toontalk shows a bird’s eye view of the city. A helicopter hovers above the city, the blades rotate, and it is accompanied by a

whirring sound (figure 5.1). The player controls the movement of the helicopter by the mouse.

The image of the city is a conceptual image. It serves to classify the houses and 'areas' of the city in a way that shows they have something in common – in this case that they are all resources for use in the program. The use of a grid system also makes a clear link between the city and a built and planned human environment, rather than a natural or organic environment: the constructed character of the city is foregrounded. The potential to build in the city is visually signified by the empty grids.

The visual resources of angle and distance or length of shot are used in the opening screen to construct the visual point of view of the user. The user (viewer) is positioned looking down on the helicopter, in a 'god-like' position above the helicopter and the city. The high vertical angle of the viewer position is suggestive of power. Through the resource of social distance the user is visually positioned nearer to the helicopter than the city which is shown in the background. The detailed texture of the helicopter is shown - a further sign of its (near) proximity to the user.

The primary and highly saturated colours of the helicopter serve to mark its salience on the screen. This is visually confirmed by the position of the helicopter in the centre of the frame.

The coding orientation of this image is used to position the user of Toontalk in relation to its elements. The strong primary colours and texture of Toontalk realise a highly 'sensory' realism: "sensory coding orientations are used in contexts in which the pleasure principle is allowed to be dominant" (Kress and van Leeuwen, 1996: 170). This is a matter of design, rather than the affordances of mode. The realism of Toontalk is associated with computer and video games and is a visual sign of the potential for user action and control in the game environment.

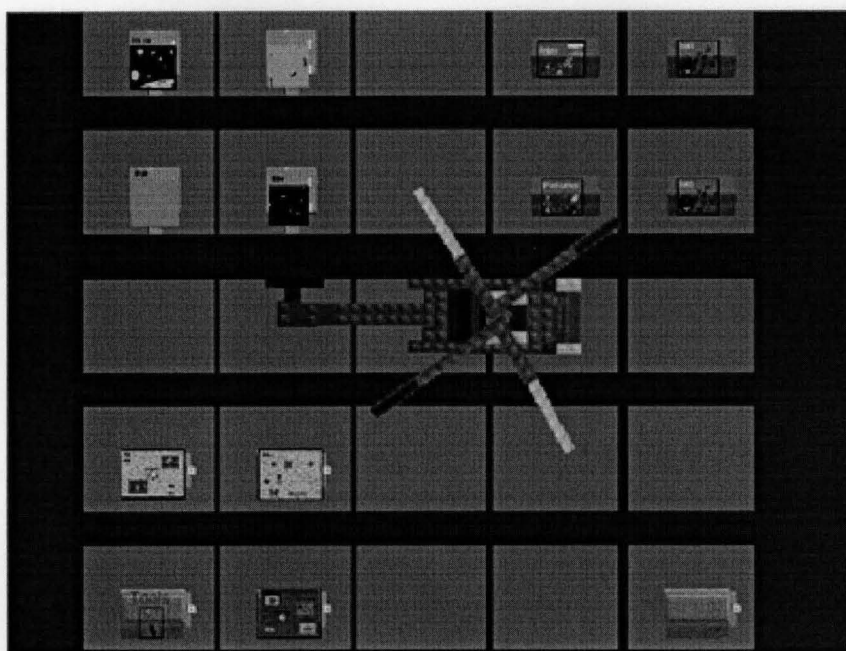


Figure 5.1 The opening screen of Toontalk: the City Level



Figure 5.2 Toontalk representation of the City at the Level of the Street as the user lands the helicopter

The modes of movement and sound are used to realise ideational and interpersonal meaning. The helicopter blades rotate at a fast steady rate and the helicopter vibrates as it ‘hovers’. The movement of the helicopter blades is accompanied by the repetitive sound of the whirring helicopter blades. Both the movement and the sound effect indicate the mechanical character of the helicopter. The movement of the helicopter and the sound of the blades mark its potential for action. Socially, the helicopter as a multimodal symbol marks an urgency of action and the ‘need’ to land. Further, the contrast between the movement of the helicopter and the still image of the flat city grid ‘below’ create a layered depth on screen. This contrast suggests the action ‘needed’ – to land the helicopter. The multimodal representation of the helicopter makes it the most salient element on the screen.

Representation of the City at the Level of the Street

The image changes as the user lands the helicopter to a representation of the city at street level (Figure 5.2). The grid-like structure of the city is realised as streets and grassed areas with houses constructed on them. The streets are represented as grey areas and the grass as green areas. As the helicopter lands, a ‘human like’ character (similar to a Lego play-mobile character) ‘jumps out’ of it. The user can adapt the visual appearance of the character: it can have either long hair, a hat, or be bald. This feature has the potential to work as a crude indicator of gender, although this potential does not have to be taken up by the user. The animated character is followed by a small toolbox. The toolbox is small and has four ‘legs’ – a visual analogy of a small animal, a dog.

As the user lands the helicopter on the ground the angle and the social distance of the image is changed. The previous ‘god-like’ viewpoint (high vertical angle) is changed to a low-vertical angle (the viewer is positioned to look down slightly on the character). The long social distance from the helicopter and the city is reduced and the viewer is positioned at a social distance from the character. In this way the

viewpoint of the user is changed from a god-like observation to that of an engaged but powerful onlooker. The user is positioned within the city.

The resources of movement are used to construct the relationship between the animated character and the toolbox and the user's potential relationship with these elements. As the helicopter lands, the movement (and the sound of the blades) stops and the character and toolbox jump out. At this point the modes of movement and sound-effect are transferred from the helicopter to the animated character (and toolbox). Modally, this makes them the most salient element on screen. The character is animated and 'walks' through the city as the mouse is moved.

The toolbox is positioned two or three paces behind the human-like character. The social distance between the character and the toolbox, and their size, is a spatial analogy of servitude. As the user moves the mouse (or joystick) the character and the toolbox move. The speed and direction of the toolbox are dependent on and mirror the character's movement. Linking the movement, speed and direction of the toolbox to the movement of the character is an actional metaphor for 'obedience'.

The soft sound of the character's footsteps on the floor is also represented. Aurally the viewer is positioned as 'near to the character' (as they are near enough to hear its footsteps). The sound-effect of the character's footsteps is a kind of 'sonic interaction' in response to the user moving the character (mouse). The multimodal representation of the animated character makes it the most salient element on the screen, again indicating the potential of the character to act on the environment of the city.

Representation Inside of a City House: Standing

When the user moves the character into a house within the city the screen image changes as shown in Figure 5.3. The image is of the inside of a room, three walls are shown (one with the door into the house) the screen acts as the fourth door in the

image, as if the user is looking into the room through it. The walls of the room are represented by the boundary of the screen.

In the scene the horizontal angle is ‘frontal’; the vertical angle is from above. The frontal angle positions the user as ‘engaged’ and the vertical angle positions the user looking down on the animated character and the room, a viewing angle that is suggestive of a degree of user power. In addition to the angle this perspective foregrounds (makes salient) the floor of the room as it occupies the majority of the screen space.

The modal resources of sound-effect also serve to foreground the floor and to suggest a closer social relationship between the user and the animated character. Once inside a house the sound-effect used to represent the animated character’s footsteps alter and the volume increases. The different sound effects indicate the move from a more absorbent external surface to a less absorbent internal one (such as wood). The increase in the volume of the sound-effect decreases the ‘sonic distance’ of the character and user.

Representation Inside of a City House: Kneeling

In order to construct a ‘rule’ (and on a larger level a game) the user has to move the character into a house and make it kneel on the floor, shown in Figure 5.4. This marks ‘rule’ in an everyday game sense of *rule* as demanding a particular location (a house) and position (kneeling) in order for the user to act. This is especially designed for affect with primary school children. At this ‘sub-level’ in the city the screen shows the floor of the house, the open toolbox and tools, and the arm of the animated character.

As the user instructs the animated character to kneel on the floor of a house, the representation of his or her point of view changes. The viewer is returned to a bird’s eye view of the floor, she or he is positioned as looking down at the floor, in other



Figure 5.3 Toontalk representation Inside of a City House: Standing

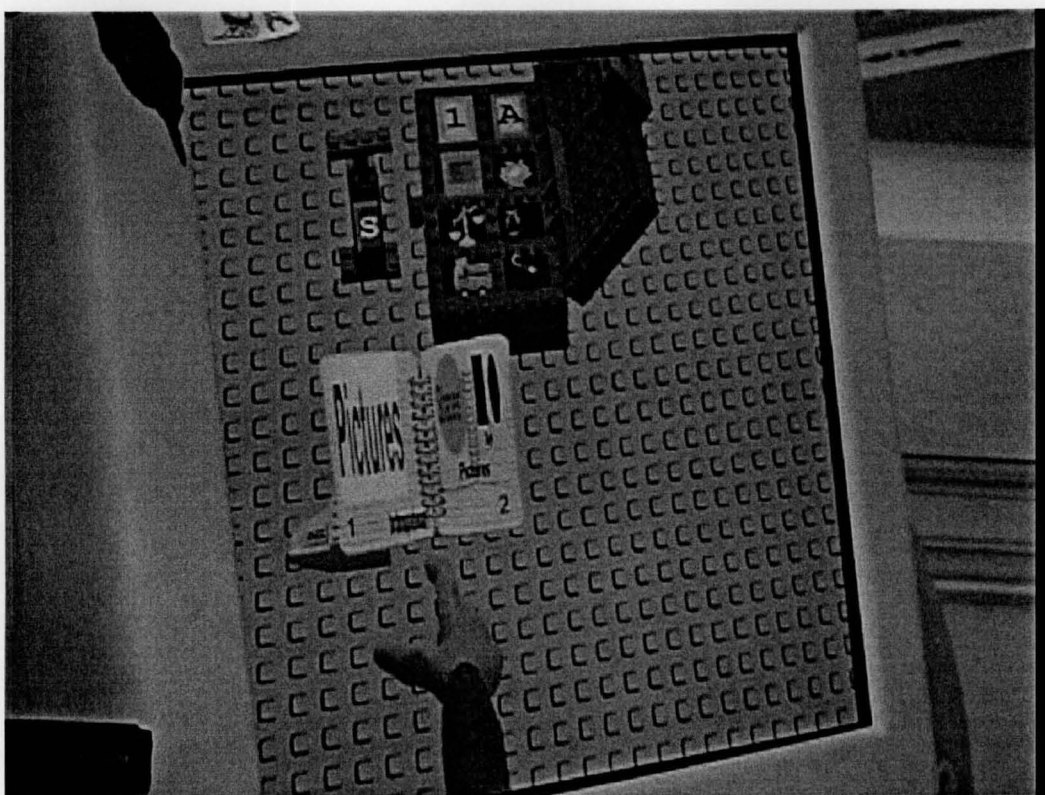


Figure 5.4 Toontalk Representation Inside of a City House when Kneeling

words the floor fills the space of the screen. Through this use of angle the user is positioned in the viewing position of the kneeling animated character. From this perspective the hand and arm of the animated character are also in view.

The user's movement of the mouse controls the movement of the character's arm (whereas in the previous 'sub-level' the mouse controls the movement of the body of the animated character). In other words, at this 'sub-level' the arm of the animated character is a metaphor for, stands for, the 'arm of the user'. This is a sign of the potential for user action within the programming application. As the player character is instructed to kneel down the toolbox 'runs' to the player's side. It opens and several tools jump out and settle onto the floor. This movement can be interpreted as an 'offer'.

Screen as a Compositional Resource

In Toontalk the screen in the different sub-levels of the city does not always display all of the compositional space available to the user. At some sub-levels the screen is the available compositional space, at others there is space 'beyond' or 'off-screen'. The ratio of the screen to the compositional space at these different sub-levels is shown in table 5.1. In the opening sequence and when the helicopter lands, the screen is not the boundary (frame) of the city image (the screen to compositional space is 1:4). As the character enters a house, the screen has the appearance of an interior of a room and the boundary of the screen acts as the boundary of the wall. Upon kneeling, the space of the floor is represented as extending beyond the frame of the screen. Depending on the screen resolution there are in fact about twelve potential screen spaces when kneeling on the floor of a house, 3 across and 4 down (for a screen resolution of 1024x768).

Table 5.1 The ratio of screen to compositional space at the different sub-levels of the city.

City sub-level	Ratio Screen: compositional space
Above the city	1:1 (full screen)
At street level	1:4
In a house – standing	1:1 (full screen)
In a house – kneeling	1:3 (screen is 1/3 of compositional space)

Moving from the city to a house produces a zooming in effect. The 1:1 ‘screen to compositional space ratio’ when inside the house is a spatial sign of containment – suggestive of safety. These levels correspond with the initial work of ‘decision’ making in Toontalk the decision ‘what can/shall I do in this house’. As the user kneels the space ‘opens up’ again.

Discussion

The multimodal resources of city level shape the concept of rule, the subjectivity of the user, and impact on the potential for learning with Toontalk.

At the sub-level ‘above the city’, rules are presented as fixed at this level of the game environment – the central elements of the city can not be altered. However like many other video and computer games no explicit rules are presented to the user as they enter it. There is no instruction manual, the user must metaphorically ‘get in the helicopter’ and ‘fly’. The rules are realised through the action of the user. The rules, what can and can not be done in Toontalk, are discovered by playing. The condition and action of a rule are left implicit at this level. The subjectivity of the user is shaped through the multimodal resources of Toontalk. The user is represented as being powerful. Through the design of the resources of visual communication and movement the user is represented *within* the Toontalk system – she or he controls the movement of the helicopter: she or he is its pilot. The user is also represented as having the potential to construct the city. The emphasis on action at this sub-level

suggests that learning happens through action, it is about doing, and ultimately about taking risks. Alongside this, the sensory coding-orientation of the game environment visually links play with learning, and learning with pleasure.

At the sub-level of the 'city street' action continues to be foregrounded in the multimodal representation of the city (figure 5.2). The concept of 'rule', condition and action are introduced implicitly at this sub-level of the game, for instance as the user 'lands' the helicopter (condition) the character jumps out (action). The multimodal design of the animated character functions to firmly locate the subjectivity of the user *within* the game system. The character represents the action of the user on screen within the city environment. The modal salience of the animated character at this sub-level, its visual proximity to the user (via the constructed point of view of the user), and the introduction of the toolbox represent the increased potential engagement of the user with the system. The multimodal representation of the toolbox as being subservient to the animated character is a sign of the user's control of the tools and the system more generally. It signals that the tools will 'do as they are instructed'.

At the sub-level of the 'city house (standing)' the visual resources of social distance, attitude, contact and setting signify the increased potential for user action (figure 5.3). The physical salience of the floor is realized at this level: it occupies the most area of the screen, the use of sound effect, the use of colour and texture. For young users of Toontalk its cultural salience (being in the right position to work) combines with these physical features to foreground the condition for programming (action) – that is, in order to program in Toontalk the user has to be in a house. The condition and action of a rule is again implicitly realized.

At the sub-level in 'a city house (kneeling)' the notion of rule is represented through action; as the user instructs the animated character to kneel (condition) the toolbox opens to reveal its contents (action). Condition is represented as something that the

user does in order to ‘make or allow’ something else to happen. Action is represented as something that the system is programmed to do in response. The setting of this sub-level of the city represents a position familiar for many children – not out in helicopters or alone in the street, but ‘alone’ in a house (room) and ‘working’ intently on the floor. The representation of the user’s degree of engagement is visually heightened here by the change in point of view and the representation of the user (from animated character to the arm of the character).

The compositional design of the screen space is a meaning-making potential in Toontalk. The player’s movement within the city environment of Toontalk results in an effect of zooming-out and zooming-in to create an environment in which ‘boundaries can change and expand’. This use of space as a resource resonates with ‘game genres’ where a small portal for example can be ‘entered’ leading into a larger space. This ‘zooming in’ from above the city, to on the street, to in the house, to on the floor, and from the helicopter, to the animated character, to the arm of the character are visual signs of the increasing engagement and potential for construction available to the user. This design of screen and compositional space represents the sub-levels within the city as a process of going deeper into a problem or activity.

The multimodal construction of rule across the four levels of the city is within the genre of contemporary computer games. Within this genre the undermining and subverting of ‘rules’ is the purpose of a game for many players (e.g. the use of ‘cheats’, etc.). The use of colour, texture, movement, and sound in Toontalk suggests that ‘rules’ are a part of play and are to be ‘discovered through engagement’. The dynamic character of the learning environment of Toontalk suggest that ‘rules’ can be built, deconstructed, and re-built – that rules need to be tested and revised. In Toontalk a stable notion of ‘rules’ as being concerned with right and wrong, correct or incorrect, is replaced with a notion of rule as that which works as a more open and creative process.

The multimodal resources of Toontalk, the hovering helicopter, the animated character, the action-activated sound-effects, and the playful visual references, are *an invitation to act*. The different ‘compositional layers/levels’ of the environment suggest ‘rules’ occur at different stages of learning through which the user can progress. A user can play a game while the tools and other resources are being manipulated, a game can also be taken apart whilst it is being played.

Ready Made Game Level

The ready-made game level includes games made and stored by users. The games are stored in one of the house in the city area and in the Toontalk notebook. As well as being games that can be played, these ready-made games serve as resources for game making. Rules, objects, and backgrounds can be copied from one game to another. I show that at another level these games serve as genre blue prints for users’ game making, rules, condition and action. Many users start their game-making by working with a ready-made game, adapting its appearance, and eventually adapting its rules – that is, moving to the level of programming rules (ref the ping-pong paper).

Toontalk makes available a set of animated tools. These tools can be used to copy and amend elements from other games, or resources stored in the Toontalk notebook. In the game mode the tools are represented as static, hard objects with a Lego-like texture in the game mode (figures 5.5 b. and 5.5 d.). In program mode when a tool is selected by the user it ‘comes to life’, it morphs into an organic soft texture, it is animated, with human like features (figures 5.5 a. and 5.5 c.). This change in texture and form serves to suggest that it is the user, not the system, who is in control of the tools.

Toontalk ‘Behaviour’ Level

Toontalk ‘behaviours’ are ready-made pieces of programming code that the user can attach to objects in a game. These behaviours are available in a system notebook, collected together as anima-gadgets. The notebook also contains sounds and images

that the user can use in their construction of games. Anima-gadgets are animated representations of behaviours that are classified as belonging together (groups of behaviours related to bouncing, or bombing, or direction of movement, and so on). Toontalk behaviours have two ‘states’; these are called the ‘action-state’ and the ‘edit-state’. The action-state of the three bouncing behaviours in the ‘bouncing’ anima-gadget is shown in figure 5.6 a. The edit state of the horizontal bounce behaviour is shown in figure 5.6 b. The default ‘action-state’ shows an animated multimodal representation of the behaviour. The ‘edit state’ reveals a static multimodal representation of the behaviour.

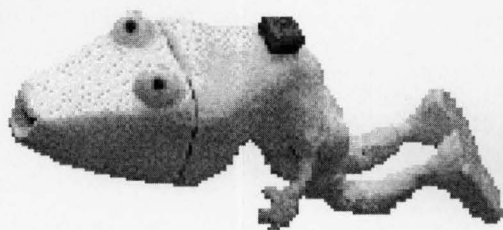
Once a behaviour is selected it can be ‘flipped’ over by the user and the user can move between the ‘action-state’ and the ‘edit-state’.

Behaviour ‘Action-State’

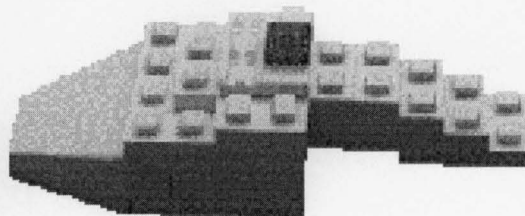
The concept ‘bounce’ is represented in the behaviour ‘bouncing’ in three modes. The mode of writing is used in the form of the word ‘Bouncing’. The mode of still image is used in the form of two images of a spring and an image of a ball. The mode of movement, in the form of three animated sequences, one of a spring moving up and down between two bars, another of a spring moving sideways between two bars, and a third sequence of a ball moving at angles within a square. These three modal representations provide different resources for the construction of the concept ‘bounce’.

The mode of writing is used to lexically name and classify the three behaviours depicted as aspects of ‘bounce’ in everyday terms. This everydayness is emphasised in the font used, Helvetica, which is often used in publications (books, web sites, et.) targeted at children.

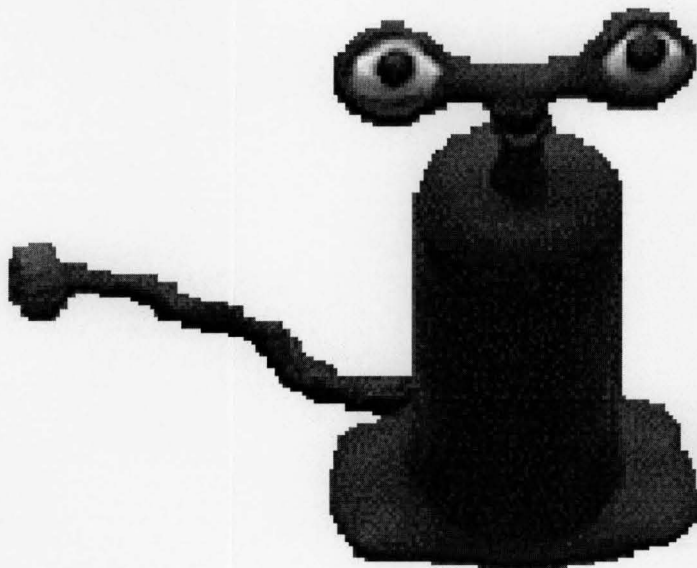
The images, taken as a set, classify the character of the concept of bounce – it is a conceptual image. However, when taken individually the images are narrative



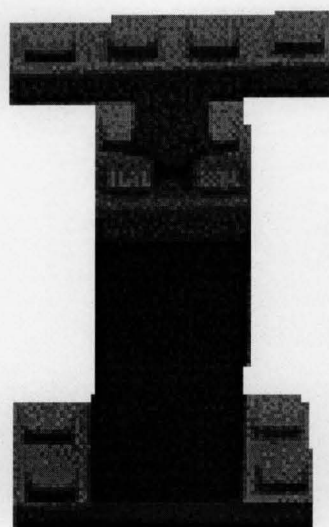
Dusty (a)



Dusty (b)



Pumpy (c)



Pumpy (d)

Figure 5.5 Two Toontalk tools, Dusty and Pumpy in animated programming mode and static game mode

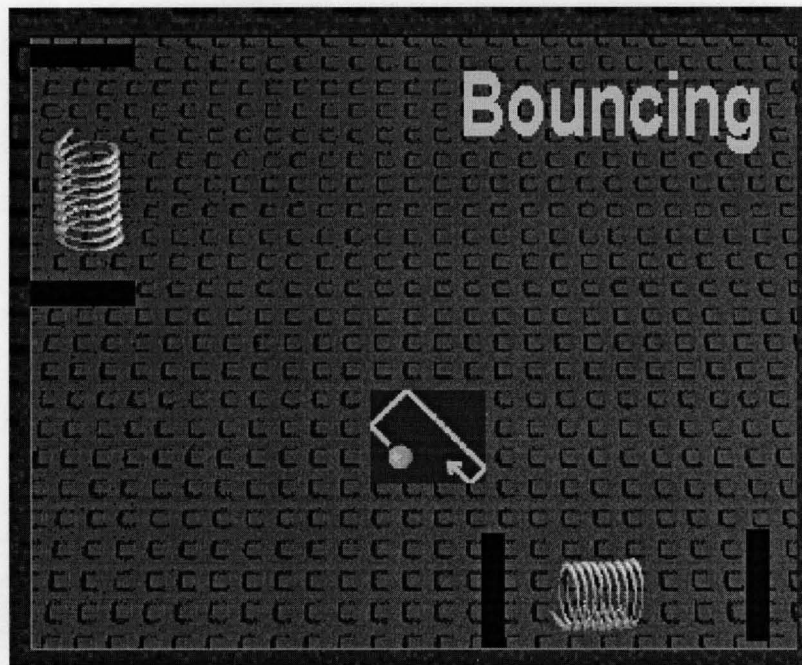


Figure 5.6 a. The bouncing anima-gadget.

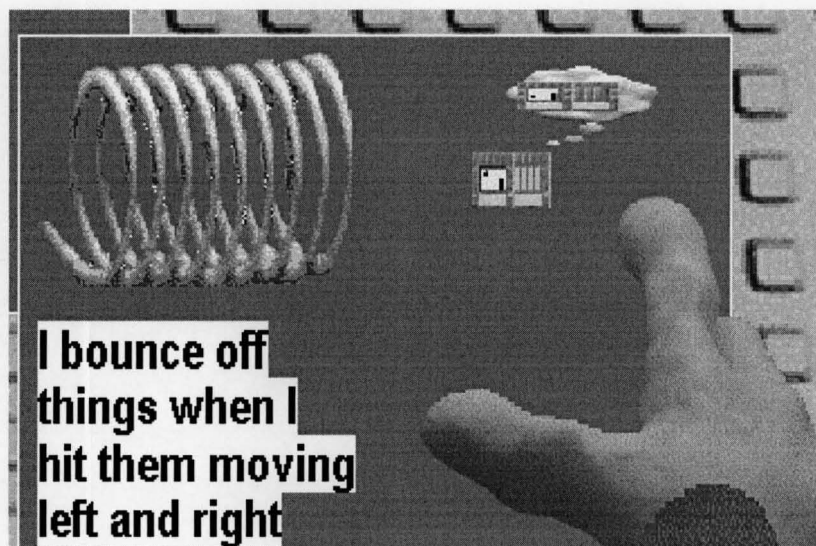


Figure 5.6 b. The edit state of the horizontal bounce behaviour.

representations that show the direction of bounce. The two images of the springs can be seen as curling vectors of action the tip of which points in the direction of movement – in the case of the vertical spring the tip points up wards and in the case of the horizontal spring it points to the right. In the third image of the ball the arrow is a visual map of the direction of the movement of the ball.

The compositional arrangement of the three behaviours in the anima-gadget is a resource that serves to indicate their potential for action. For example, the vertical spring occupies a vertical block of space along the vertical axis of the screen and the horizontal spring occupies a horizontal block of space along the horizontal axis of the screen. The strong frame of the anima-gadget serves to visually classify the behaviours as a set.

The images are represented from a frontal angle. The springs and ball are represented in a diagrammatic style with little detail and limited shading. These aspects are often associated with scientific representation of information. In this way the behaviours begin a visual move toward incorporating a scientific or technical coding orientation.

The ball and the two springs are coloured a fluorescent lime green. The barriers that the springs move against and the square that the ball moves within is coloured a dark violet. The intense luminosity of the green colour contrasts with the absorbent darkness of the violet. The colour co-ordination of the elements in the three behaviours signifies their classification in the anima-gadget ‘bouncing’. The use of intense and highly saturated colour in the behaviours is highly sensory and this works along side the aspects of technical coding outlined above.

The animated sequences of the springs movement between two bars, and the ball contained within the square, work to give meaning to the entity ‘bounce’ in the context of the Toontalk program. The movement is regular, repetitive, controlled and contained.

Behaviour ‘Edit-State’

In the ‘edit-state’ the mode of movement is removed and instead this movement is described in the mode of writing and the mode of static image (although the image of the robot in the code represents a generalised potential for action). The written text can be transformed into spoken text in Toontalk. The ‘edit-state’ of the bounce behaviour that is shown in figure 5.6 b. consists of a static image of a spring, a written description, and a piece of Toontalk program code.

The written description reads ‘I bounce off things when I hit them moving left and right’, and the image of the spring. This lexically expands the word ‘bouncing’ in the action-state into movement and direction. The use of ‘I’ reflects the system requirement of Toontalk that a ‘behaviour’ (ready-made piece of program code) be attached to an object and the personification of these objects. The written text can be transformed into a spoken text. The voice is high pitched, slow, even toned, and regular pace: in the form of an anonymous ‘female’ instructor.

The visual representation of the green spring in the action-state also appears in the edit-state. However in the edit-state the image of the spring is bigger and the barriers represented in the action-state are not present. Visually this heightens the power of the spring and ‘removes’ the constraints on it. The ubiquitous textured background of the Toontalk environment is substituted with a flat grey background in the edit-state of behaviours. This representation serves to decontextualise the spring and, I want to argue, that semiotically this heightens its potential for action.

The Toontalk program code is represented in the edit-state of a behaviour: the program code is represented in the top right corner of the edit-state as shown in figure 5.6 b. The image of the program code is too small to read when it is on the behaviours; in order to be read it has to be selected and ‘taken off’ by the user. Nonetheless the numbers, boxes, and robot thought bubble is visible in the edit-state of a behaviour.

The four modes of writing, image, ‘program mode’ (the multimodal representation of the program code is discussed in the next section of the paper) and speech are not given equal salience in the behaviour edit-state. The ‘size’ of the block of writing, the image of the spring, and of the program code differs. The image and the written text occupy the same amount of the screen, while the program code is approximately half their size. The spoken mode is not visually indicated on the behaviour. The composition of the edit-state of the behaviours allocates specific spaces to particular modal realisations. Kress and van Leeuwen’s (1996) theory of compositional information values (outlined in Chapters Two and Three of the thesis) can be usefully applied to the edit state of the bounce behaviour shown in figure 5.6 b. The image is positioned in the top left quarter of the composition, the writing is positioned in the bottom left quarter, and the program code is positioned in the top right quarter as shown in figure 5.7.

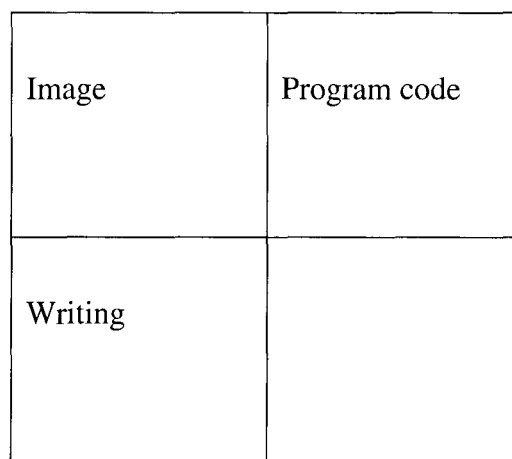


Figure 5.7: The modal division of the bounce behaviour edit-state.

As figure 5.7 shows, the top-left position of the image of the spring suggests that its information value is ‘given and ideal’. In other words it is presented as something that the user already knows, an agreed departure point for the message, and the idealised essence of the concept of bounce. This demonstrates the potential of images

to mediate the action and edit state of a behaviour. The bottom-left position of the written text suggests that its information value is ‘given and real’. Compositionally the writing is presented as something familiar to the user and a more ‘down to earth’ explanation of the concept of bounce. In contrast the program code is presented as new and ideal. That is, it is represented as something new and not yet known to the user – the information that is ‘at issue’ and the generalised essence of the information and ideologically most salient aspect of the behaviour. The compositional arrangement suggests a valuation of the modes of representation in the context of the behaviours, and an idealised progression to program code.

Discussion

Moving from the action-state to the edit-state is analogous with opening up a car-bonnet and looking at its engine. The increase in the amount of writing in the edit-state, together with the reduction in the saturation of colour and texture and context, and the introduction of the program code combine to indicate a technical coding orientation. This use of colour, texture and context in the sensory character of the action-state and the Toontalk environment are more generally ‘toned down’. In this way mode and modal resources are used to indicate a shift in the domain of knowledge. In other words the multimodal representation of the action-state and edit-state of the behaviours shape the entity rule and the resources for learning in particular ways.

The modal representations of ‘bouncing’ in the action-state of the behaviour provide different resources for the construction of the concept ‘bounce’. The static image of the springs and the ball visually bring forth (or specify) particular meaning potentials and at the same time, visually, dismiss others. The modal resources of image and movement are designed to realise the potentials of ‘bounce’ as a mechanical, regular, ordered entity, rather than as an organic, unpredictable bouncing (like that of a rabbit). The modal resources of colour are also used as a sign of action in the behaviour. The intense green can be interpreted as a signifier of the energy of the

springs. The absorbent violet can be interpreted as a signifier of the lack of energy of the barriers. The children's everyday experience of 'bounce' as a general uncontrolled movement, such as a highly bouncy ball is excluded from the Toontalk concept 'bounce'. The resources of image, movement, and writing work together to define 'bouncing' within the mathematical paradigm of the system.

In the action-state the multimodal representation of 'bouncing' is not formulated as a rule but as an action. Action is foregrounded. Condition is entirely backgrounded in the representation, in a sense condition is represented as context (the barriers that are 'hit' by the moving object).

In the bouncing behaviour edit-state the colour and image of the spring is the same as that of the action-state. Image serves visually to mediate the two states of a 'behaviour'. In the edit-state the mode of writing is increased and given equal salience with the image. The resources of compositional information value are designed to modally divide the edit-state of the bounce behaviour. I show that this composition signifies a valuation of the modes of representation in the context of the behaviours, and an idealised progression from word to image to program code.

In the edit-state the image of a spring continues to foreground action rather than condition. The multimodal representation of bouncing in the edit-state is however formulated as a rule in terms of condition and action. The writing 'I bounce off things when I hit them' presents the behaviour as a rule. The use of 'I' and the decontextualised image of the spring both suggest that behaviour is a property *belonging* to an object. In programming, the work of the student is to specify which game-object the 'I' refers to. The user is required to select the object that the bounce behaviour should be attached to. The entity rule is also represented in the program code shown in the top right quarter of the edit-state - which also although not foregrounded by its size, is present nonetheless.

In this section I have analysed and discussed the multimodal resources of Toontalk game mode (at the level of the city, the ready-made games, and the behaviours) and how these shape the resources for learning, the subjectivity of the user, and the entity rule. In the next section I present a multimodal analysis of Toontalk program mode.

Program Mode

Toontalk is a multimodal object oriented programming system and the program mode combines animation, still images, some written Lexis, and numerical symbols. To show how the modal resources of the application realise the entity 'rule', I analyse the realisation of a 'rule' which children often use in their games in each program, namely 'move the object to the right when the control button is pressed'. The rule 'move the object to the right by 15 units when the control button is pressed' is realised through animated ToonTalk code, as shown in the sequence in figure 5.8.

The program mode includes a robot. The visual representation of the robots as having a 'mind' (visually represented as a thought bubble), hands, eyes, etc. is a signifier of them as having a 'trace of human-ness'. The large open eyes of the robot stare out at the user making a visual demand for something from the user, in this case a condition. The piece of program code shown includes a series of three boxes held by the robot - the goal of the robot's action. The first of these boxes contains the word 'no' this is a sensor showing that the control key is not held down. (In the second image in the series the key is held down and the word 'yes' appears in the box.) Two of these boxes contain numerical representations of the horizontal position sensor of the object, and the number (units of distance) to be added on to this position, that is, to make the object move. The third object that is represented is an image of the control key this is the anima-gadget image of the behaviour 'I move to the right when the control key is pressed'. The robot is the most salient element on screen due to its features, size and movement. The spatial arrangement of the elements on the screen is such that there is no clear rule or reading path coded in the image.

Text cut off in original

<p>The ctrl key is not pressed, the robot's conditions are not met so it waits.</p>	<p>The ctrl key is pressed, the robot copies the number 15 ...</p>	<p>... and drops it on the horizontal position sensor. Bammer the mouse adds the two together.</p>	<p>The position sensor is now 532 (i.e. the object has moved 15 units to the right). If the ctrl key is still down the robot repeats its actions.</p>

Figure 5.8 The Toontalk code for moving an object to the right when the control key is pressed: program mode

The robot is animated: it 'waves' at the user, and it 'hovers'. These non-directed and symbolic movements of the robot represent it as a generalised potential for action (enacting the rule), and for interaction with the user.

Condition

The condition of a 'rule' is met when all holes in the input box match those in the Robot's thought bubble. The first condition (i.e. 'when the control key is pressed') is represented in writing and animation by the flashing sensor displaying 'yes' or 'no' depending on whether the control key is being pressed or not. This condition is met when the sensor shows 'yes', thus matching the condition in the thought bubble of the robot. The second and third conditions simply require that any number be in the subsequent two holes. In the Toontalk programming mode therefore, a condition is met through 'sameness', indicated by the matching of the boxes. The modal affordances of the program mode are orchestrated to produce sameness. While the condition is not met the robot continues to wave and hover.

Action

The modal affordances of movement, in the form of animated robots within the system, are central to the realisation of the action. When a robot is trained to carry out a 'rule' the user 'enters' the 'thought bubble' of the robot. In this domain the user's movement of the mouse controls the movement of the robot and its arms. Through movement the robot is represented as an extension of the user and the user is represented (positioned) *within* the programming mode itself. This positioning of the user is both a result of the system design and the modal affordances of the system.

The action 'move 15 units to the right' is 'carried out' by the robot. The robot copies the number 15 with the wand tool, it moves to the central box that contains the horizontal co-ordinates of the object, and drops the number 15 onto it (the box containing the 517 figure). The robot is the actor engaged in a directed action on the box. The 'addition' of the two numbers is 'carried out' by the tool 'Bammer'- an

animated character tool within Toontalk – a mouse with a large red mallet. Bammer runs out and bangs the 15 onto the 517. This joins the two numbers. The number in the middle box changes to 532, a representation of the ctrl key moving to the right. The user can see both the mechanism of the *rule* and its outcome: the animated robot picking up a number and placing it on top of the horizontal co-ordinates of the object, the animated tool Bammer banging the number in place, and the sensor number co-ordinates change.

Toontalk allows multimodal representation of a rule in several ways. It provides an option for speaking text description of the rule. Multimodal representations of rules as modular sub-behaviours are provided. The rule ‘move’ is an example of Toontalk behaviour and is shown in figure 5.9.

Rule

The Toontalk program mode does not label ‘condition’ and ‘action’ through the representation of elements. The sequential arrangement of the boxes and numbers as ‘rule’ on screen (see Figure 5.8) does however suggest the sequence of rule from left to right. This is emphasised by the spoken text of the rule if the user selects it. The movement of the robot and the Bammer tool serve to disrupt the linear arrangement of the numbers and boxes. The multimodal and multi-directional elements on the screen

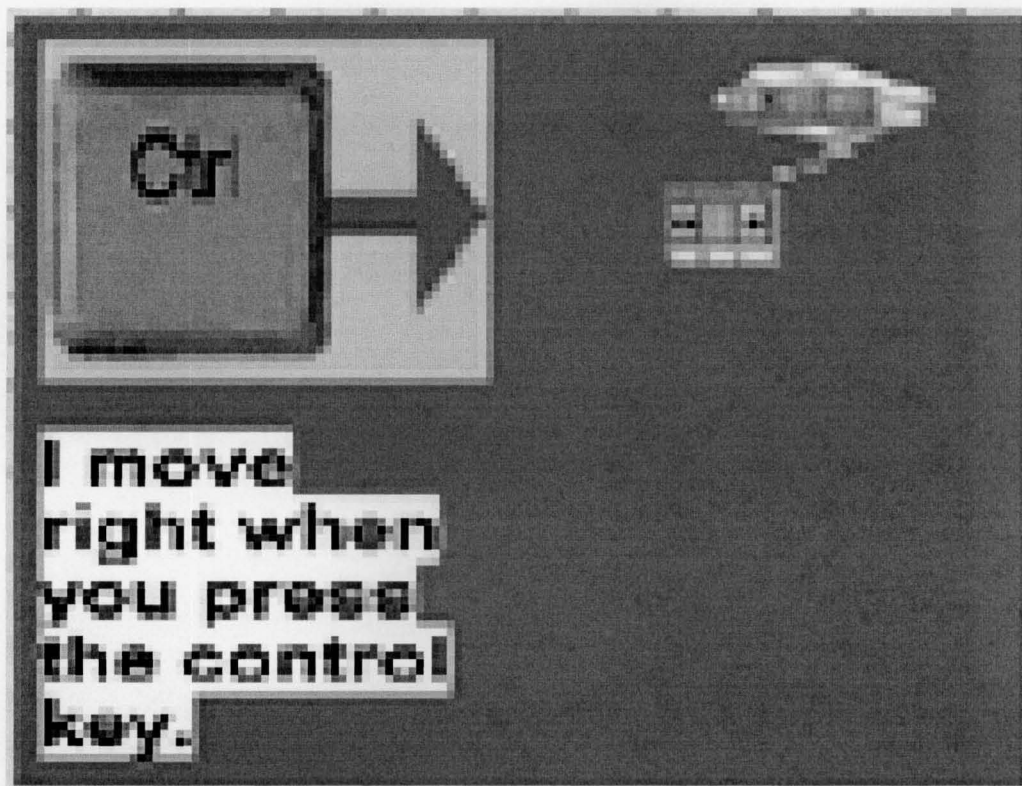


Figure 5.9 Multimodal representation of 'move' behaviour in Toontalk

mean that to some extent the user has to determine what is condition and action for her/himself. Rule is represented as a holistic entity and the path for reading this is less fixed than in other computer programming systems such as Imagine Logo and Pathways.

Genre and Realism

The genre of Toontalk is that of the animated cartoon. Bammer is an everyday cartoon representation of ‘add’, that is, banging things together, squashing them into one form. In this way, the robots and Bammer (and the other tools in Toontalk) mediate the mathematical world represented in numbers and sensor positions and the everyday world of the child user through the form of animated cartoons.

The genre and the form of realism of Toontalk offer the user two ways of thinking about movement, one, an ‘everyday’ concept of movement, and the other, as a mathematically expressed concept. The entity movement is constructed both through the conceptual resources of science/physics and children’s everyday experiences. The modal affordances of Toontalk do not require the user to imagine the movement (as is the case in other programming applications such as Imagine and Pathways), the user can see the movement. Phenomena are represented through the iterative interaction between the everyday and the mathematical. In Toontalk the representation of things that have significance in children’s everyday worlds are represented as being significant alongside that which is significant within mathematics. The user is able to attend to the mathematical code via its actional realisation. This iterative move between concepts and the modal affordances of the program mode provide a potential for the user to make links, to come to understand ‘rule’ as both a mathematical and an everyday entity.

The representation of the elements of the rule ‘move 15 units to the right when the control key is pressed’ in Toontalk program mode discussed above, are summarised in table 5.2.

Table 5.2 Summary of the representation of the elements of rule in Toontalk.

Elements of rule	Representation in Toontalk
Condition	Trained robot, thought bubble and animated key sensor
Action Movement	<ul style="list-style-type: none"> • The robot • Horizontal position sensor co-ordinates • Units of distance as number • The movement of the co-ordinates • Bammer hammering
Direction	<ul style="list-style-type: none"> • Value of number to be added to position sensor • The function of addition • Movement of co-ordinates
Object	Visually depicted
Spatial arrangement of rule elements	No systematic order of direction
Genre of rule	Animated cartoon
Realism of rule	Sensory
Agency of user as represented in rule	User <i>in</i> system (i.e. robot as extension of user)

Discussion of Program Mode and Rule

The modal affordances of image and movement in the representation of ‘condition’ in pathways and Toontalk represent the user as an agent in the design of ‘rules’. In Toontalk the user is represented as being within the system directly manipulating its resources. The program configures the degree to which the entity ‘rule’ is the product of human interaction (control) in specific ways that in turn position the user to the understanding of ‘rule’ and the task of programming itself.

In Toontalk 'rule' is represented as an entity that expresses potentials for action. The realisation of rules in Toontalk marks the relation between mathematical and everyday concepts, while other applications such as Logo Imagine represent 'rule' as a mathematical explanation that underlies everyday experiences. Toontalk provides the user with the potential to move between everyday and mathematical concepts on screen, without privileging either. Toontalk represents 'rule' as a way to connect (make sense of) the everyday *and* the mathematical.

An everyday notion of 'object' is present in Toontalk, where an object has to be visually depicted – it has to 'be' something. In Toontalk the link between 'rule' and object is maintained through the object's sensors which provide inputs to the robot. This link is two-way, for example, if the object is picked up and moved, the horizontal position sensor will change, conversely if the value of the latter is altered, the object will move. A rule can be transferred from one object to another by placing it on the back of an object. The sensors in the input will now refer to the new object. An object is thus named in two ways first by its presence on the screen as an entity and secondly in mathematical terms as a set of descriptions through its sensors, (e.g. position, size, shape etc.).

The entity 'rule' is shaped by the multimodal configuration of the Toontalk program mode. The seemingly fixed unidirectionality of the written text (from left to right, and top to bottom in the west) present in other computer programming applications (for example, Imagine Logo and Pathways) is not apparent in Toontalk. In Toontalk the arrangement of the different elements of programming mode have multiple directionality, which disturbs the logic of the traditional 'line' of western writing as a 'textual/written unit' in which readers move (their gaze) from element to element from left to right. Within Imagine and Pathways, 'condition' and 'action' are represented as distinct entities through the sequential order of the 'rule'. In Imagine Logo this is a consequence of the modal representation and of the move from left to right in western writing. In both instances the condition is foregrounded by this

sequential order. The modal affordances of Toontalk do not represent 'rule' separately as condition and action; the spatial dimension of the image and movement represent 'rule' as a fusion of condition and action in both space and time.

In Toontalk the user's task is to select and order the elements of 'rule' made available to them in order to make sense of the representation of the entity 'rule' on screen. Whereas the entity 'rule' is represented as a fixed stable entity within Imagine and Pathways (consisting of elements organised in a clear relationship with each other) this is not the case in Toontalk. In Toontalk, 'rule' is represented as a more open entity; the elements and their relationships to one another generate more open potentials for the user's design. These different arrangements of the elements of the entity 'rule' suggest that the process of rule making in Imagine and Pathways is constrained in quite different ways to rule making in Toontalk. Rule making in Toontalk is a matter of conceptual design, multimodally realised, and part of this design is the design of the relationship between hierarchical composition of rules and behaviours.

The subjectivity of the user is effected, and potentially reshaped by, the multimodal design of Toontalk. Toontalk is realised within a sensory animated cartoon/game genre (placing programming clearly within the frame of game). This enables the user to work with the principles of game via the mediating tools of the program (the robots, wand, Bammer etc) to engage with mathematical concepts. I suggest that the genre of the three programs, like other kinds of applications for new technologies, can bring forth (provide the potentials for) different genres of engagement with them.

Program applications provide users with different kinds of principles for organising and understanding the world, different coding orientations, each of which is appropriate to the different versions of the 'world' that the program represents as 'real'. Toontalk foregrounds the social world, the social forces of people and community (realised by the Toontalk representation of the user on screen, the robots,

the personified tools and the overarching metaphor of a city) and indicates that it is underpinned by the mathematical laws of natural phenomena.

In summary, in Toontalk the work required of the user is to move between the common sense conceptions of the everyday and mathematical formulations of them and vice versa, to work with the mediating tools of the Toontalk system to re-articulate the everyday in mathematical terms. The system enables the user to hold both versions of the world in mind/on screen and to learn through iterative movement between these two versions.

The relationship between program mode and game mode is realised in the multimodal design of Toontalk. The different levels in the game mode use the spatial dimensions of screen in different ways and have different functions within the game mode. The design of the relationship between the program mode and the game mode itself contributes to the construction of the entity 'rule' in a programming application – the rules become differently configured entities in this new mode. In turn the relationship between program and game mode requires different kinds of 'work' from the user as she or he moves between them and shapes what it means to be a learner in each system.

The activity of the student with the Toontalk system creates different kinds of spaces. The analysis of students game building with Toontalk presented in the second part of this chapter shows that students create different 'spaces of activity' on screen when using Toontalk, including 'game design space', 'game play space', 'game construction space', and 'resource construction space'.

The user seated on the floor of the house can engage with both the program mode and the game mode simultaneously. The user can observe the mechanism of the programming and the result of the programming at the same time. At this level of

game mode there is no boundary between ‘game construction’ (programming) and ‘game space’ in Toontalk.

This first part of the chapter has focused on the multimodal resources made available in Toontalk and the potential of these resources to shape the entity rule and the subjectivity of the player. In the second part of this chapter I explore how two students take up and make use of these multimodal resources in the construction of a game and rules.

Part 2: Designing and Making a Game in Toontalk

When a learner sits alone in front of a computer and engages with the resources on screen there is more going on than the interaction of that individual with the screen. The activity of the learner is the complex outcome of the interaction of the learner with other people, tools, and the cultural and institutional rules and norms of the community that they are situated within (Russell, 2002). With this complex web of activity in mind, learning can be thought of as the outcome of interactions with others mediated by tools in culture. The computer is one such tool, and the effect of tool mediation is one way to understand the complexity of the relationship between the learner the screen, and the content of ‘what is to be learnt’ in the move from page to screen. Understanding the impact of the computer as a ‘mediating tool’ is central to understanding computer mediated learning (Saljo, 1999).

This chapter focuses on how the multimodal resources of Toontalk re-organise or re-mediate the ways in which students learn (produce knowledge). More specifically, it explores how two students’ conception of ‘bounce’ develops as an emergent mathematical concept through engaging with these resources. I suggest that the students understanding of ‘bounce’ is shaped (mediated) by the multimodal semiotic resources of Toontalk, as well as the everyday knowledge and experiences that they bring to their interaction.

Designing a Game

The chapter focuses on two students, Emily and Rachel (age 7 and 8 years) building a game from scratch using a limited set of eight anima-gadgets (anima-gadgets are collections of ready-made pieces of code – or ‘behaviours’). Initially, the students were given worksheets that directed them to explore the functionality of the anima-gadgets. They turned each anima-gadget on and watched the behaviours while discussing them with each other and the researcher. They mapped out the design of their game, through talk, drawing and writing. The students were encouraged to be specific about what the game would do, and how the components (behaviours) would make the game work. Finally, the children were asked to draw a picture and to write the rules of the game.

The two students made the game over three one-hour sessions. In the first session the game is designed on paper and then visually on screen. In the second session the students concentrate on one aspect of programming - making the bullets bounce. In the third session the students program the ‘blow up behaviour’ on the bullets and complete the game. In a fourth session the game was shared and re-designed with students in Sweden. The collaborative game design with students in Sweden is discussed elsewhere (Noss et al., 2002) and is not focused on in this thesis.

Designing the Game on Paper

The students’ representation of bounce through the medium of pen and paper described below differs from the traditional design of bounce in a math's textbook; it is already shaped by the centrality of the demands of the screen. The students’ design of the game on paper is shown in figure 5.10.

Design in Written Mode

Analysis of students’ writing shows that the sequential affordances of writing realise the entity ‘rule’ in which the elements of the game are named - the alien, the little

figure, the bombs, the 'place', and the 'bars'. Through writing the students represent the game as a sequence of events and of actional relations between named elements.

The little figure will move around the place and when the alien finally catches it. It makes an explosion noise and the bombs go sideways by arrows and then if you touch the bars it goes different ways and when you touch the bar it makes a noise.

The entity 'bounce' is realised through the interaction of these elements but it is not foregrounded. In written mode five actional relations are realised: (1) the alien catching the little figure; (2) It (the little figure) makes an explosion noise; (3) 'you' touching the bars (4) 'you' touch the bars again (4) it makes a noise. The alien and the bombs are represented as agentive - they 'catch' or 'go' and 'touch', and the agency of the user 'you' is merged with that of the bombs. In this way the bombs are personified, for example "...you touch them...". The actional relations and use of personification realise different semantic roles for the elements in the game (the bomb, the alien, the little figure). It establishes (and emphasises) the activity of the bomb and the inactivity of the bars beyond the 'reaction/response' as the goal of the action of the bomb (and the user). Themes in the game are established through the students' different use of modes in relation to the elements in the game, in particular the theme of strength and weakness. The students' use of the mode of writing foregrounds the little figure and its movement (in the theme structure of the first sentence) and the combination of the descriptive adjective 'little' and the vague 'move around the place' establish the little figure is the weaker element in the game. The use of 'catch' and the sequence of the sentence indicates that the role of the players is that of the everyday game-genre of catch/tag (which exists both on and off screen).

The entity bounce is linguistically represented as, "the bombs go sideways by arrows and then if you [the bomb] touch the bars it goes different way". 'Bounce' is represented as a matter of movement and change of direction when something is

touched. The modal affordances of writing do not demand that the cause of the change in movement - the user, the bomb, or the bars - be made explicit.

Design in Still Image Mode

The resources of drawing offer different representational affordances than those of writing and these 'demand' a different representational commitment of the students. The image is a narrative representation of an alien 'acting on' a little figure via the vector produced by the line of bullets that emanate from the alien. (A vector is a line, often diagonal, that connects objects or participants in an image. The vector expresses a dynamic, 'doing' or 'happening' kind of relation.) In drawing, the students are 'forced' to depict the size, shape and features of the elements of the game: the alien, the little figure, and the bombs. They are required to produce a differently conceived representation of the 'little figure', it becomes a little animal (not much bigger than a bullet), with two legs, two arms, two big ears, a head and a body.

The spatial affordances of image require the relations between these elements to be specified. Through the use of the visual compositional resources, size, and detail, the students increase the power difference between the little figure and the alien. The alien is the most salient element in the image. This is realised by its central position in the composition, its size - it is about eight times bigger than the little figure, the detail of the drawing, specifically the inclusion of human-like features (eyes), and the representation of direct eye-contact between the alien and the viewer of the image.

The affordances of drawing with pen on paper shape the students' representation of movement and noise. Through their drawing they visually extend the written entity 'bounce'. They draw on the genre of time-lapse images, as the visual trace of a sequence of movement over time, to represent the movement of the bullets/bombs. They represent 'explosion' in a visual cartoon genre of 'effect', the shaking of a near space around the little figure by a 'wiggley' line around the form. Through these visual resources the entity bounce is visually represented as 'ricochet'. The direction

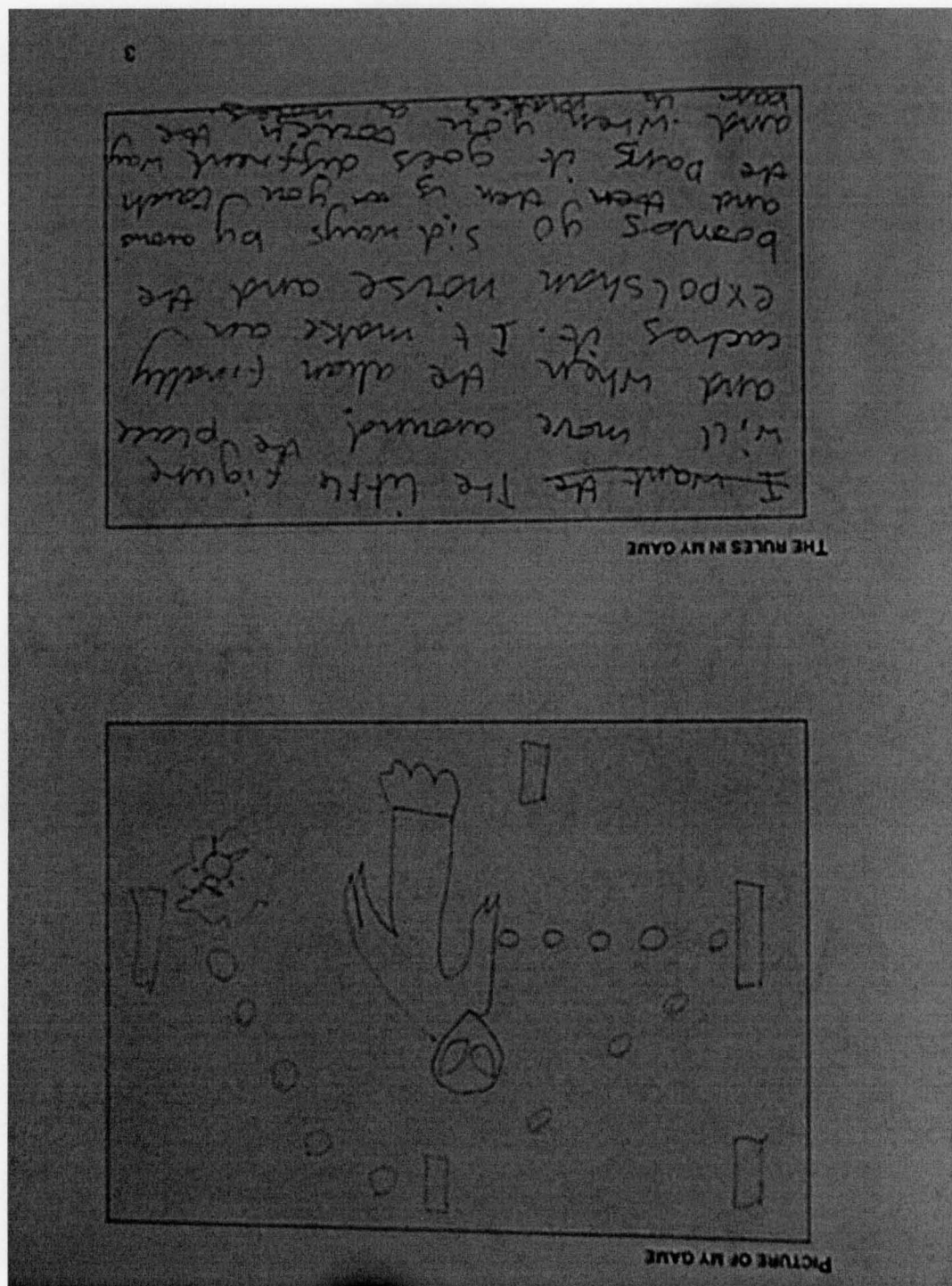


Figure 5.10 The students' design of the game on paper

of the movement of the bombs/bullets is realised spatially in relation to the static bars, the alien, and the little figure.

The affordances of pen and paper both enable and constrain the design of the game and the students' interaction with these affordances brings forth different elements of the game, ideas of 'bounce' (and notions of game itself). The students then design the game with the resources of Toontalk.

Designing the Game on Screen

Toontalk offers the potential for temporal sequences of movement across/within the space of the screen, which realise visual rhythms, and the illusion of three-dimensionality. The affordances of Toontalk demand that the students re-specify the generalised elements of their game design in pen and paper. The visual design of the game (figure 5.11.) and of the elements and their spatial relations, in session one is not 'merely' a matter of decoration: it is the design of the game narrative itself.

The "little figure" needs to be fully depicted and the students select an image of a little dog from the Toontalk 'notebook' of images, a motivated sign. The dog is a sandy brown colour, it is depicted wearing a rocket strapped around its waist and is shown flying, and wears a pair of sunglasses. The alien selected from the notebook is green, smaller, and a more monster like with a large trumpet shaped nose and four eyes (and less human) than the original drawing of the alien. Similarly the bombs of the original design are transformed in the move to the screen into small white bullets. The background of the game named in the writing as 'place' and represented in the drawing as grey rectangle (screen) is represented by an image of the planet Jupiter. The planet is brightly coloured in shades of orange and red, both hot warm colours (hence the narrative thread of the dog's sun glasses). The frame of the game on screen is transformed from a rectangle to a circle – emphasising the planet location of the game.



Figure 5.11 The student's visual design of the game with Toontalk on Screen

Through their engagement with (and selection from) the visual resources of Toontalk the students create a strong visual game narrative that is emergent in the design on paper. A 'stranger/outsider' (the little dog) visits a planet where the (native) alien defends his territory. The outsider status and the vulnerability of the little dog are visually marked by its need to wear sunglasses (against the heat of the warm planet – indicated through the modes of colour), the external power of the rocket to enable it to fly, and its small size. This narrative is expressed in Emily's spoken narrative at this stage of the design.

I want there to be little bars where if you hit it, it [the ball] goes another way and another way and another way and I want there to be another little creature that he tries to kill.

The students designed the visual frame of the game (and through it defined the game narrative) and moved on to consider the movement of the elements. Interestingly, the move from the page to screen changes the fate of the little figure who, instead of being caught, will now be killed, reflecting a change in game genre from the genre of board game to the genre of adventure/action game on the screen.

The programming function and affordance of Toontalk demand that the students specify (select) the action and movement of each game element. The students select the 'shoot in four directions' anima-gadget for the behaviour of the green alien; the initial movement of the alien in the written narrative of the game-design is transformed in Toontalk into "fires bullets". The vague movement of the "little doggy...around the place" is now specified as moving left to right in a straight line by the students' choice of the anima-gadget 'move left and right with shift and control'. In order for an object to have functionality in Toontalk the user needs to put a 'behaviour' (a ready-made piece of programming code) on the back of the object. This demands that the user decide what game element is going to 'have' the behaviour, raising the issue of agency.

The students play the game, and realise that the bullets do not move in the way that they want them to move, and Emily says, “but we need to make that [the bullet] bounce”. The students have drawn the movement of the bullet, described it in their writing and talk, and traced it on the computer screen with their fingers. However, this is the first time that Emily has used the word “bounce” in the process of designing the game. Her specification of the movement in this way may be brought forth by the classification of movement in the Toontalk environment, one of which is ‘bouncing’. As Emily discusses the behaviour ‘bounce’ she re-names the object “ball”. The student’s engagement with the mode of speech forces her into lexicalising the general notion of ‘movement’; and this brings forth a change in the semantic field that then selects the object of discussion.

The Design of ‘Bounce’

The remainder of this chapter focuses on how the students’ concept of ‘bounce’ develops through their interaction with the resources of Toontalk, each other and the researcher.

In session two of the game-design, the students program the bouncing movement of the bullets. The session consists of six framed activities, punctuated by the students playing the game.

Frames of activity in Session Two of game-design

Play game

- Plan the movement of the bullets and the position of the sticks.
- Make the sticks and position them on the game.
- Read the bounce anima-gadget.
- Attach the bounce behaviour to the sticks.

Play game

- Attach the bounce behaviour to the bullets.

Play game

- Realise and specify the problem with the bounce.

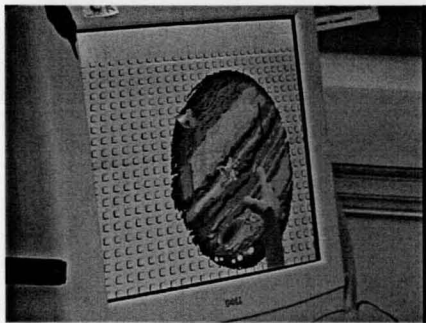
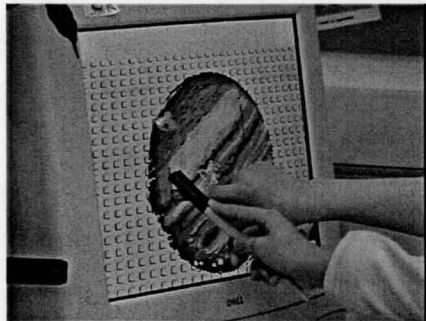
Planning Through Gesture and Speech

The two students play the game but the bullets do not move in the way that they had wanted (this episode is described in transcript 5.1). The two students stop playing the game and begin to plan the movement of the balls visually through their gestures on the screen and their talk. The students' gestures are directed at the screen and these repeated gestures highlight the central elements of the game the 'sticks', the dog and the alien. Initially in this episode the two students' talk and gesture is strongly co-ordinated as they show the desired movement of the bullet.

Later in the episode the students' gestures and talk differ (marked with * on the transcript). Rachel traces the bullet moving in a vertical line down to the bottom-right stick and from there in a horizontal line to the dog. She then quickly wiggles the pen to indicate either somewhere in that area or a generalised 'other place'. This gesture, a non-directed gesture, contrasts with her previous gestures which have been in straight lines and slower in pace. Emily holds her finger on the top-right stick and then traces an 'imagined' stick to the right of the alien and gestures the bullet bouncing from the top-right stick to the bottom-right stick. She then gestures the line of movement trailing off past the dog. This last gesture is significantly slower in pace than the previous ones.

The students' gestures with the screen are visually mapped in figure 5.12.

Transcript 5.1 Students planning the movement of the bullets

Time	Person		Speech	Gesture with screen
12.21	E		Good	presses 'up' arrow key – alien fires ball presses 'left' arrow key – alien fires ball which moves through the 'stick'
	I		but <u>we need to make that</u> bounce, and <u>that</u> – ooh <u>good</u> we can see the eye So what's the next thing you all want to do?	points finger at left stick on screen points to "little doggy" points at image of 'Jupiter's eye' on screen
	R		Well The bullet <u>shoots</u> to <u>there</u> to <u>that</u>	points with pen at alien points with pen at left stick points with finger at left stick points with pen at top-right stick
	E			

R

to there

*points with finger at top right stick keeps

E

to bounce up to there

finger there

still pointing at top-right stick

R

and then that

points with pen at bottom right stick

bounces to there

points with pen at dog

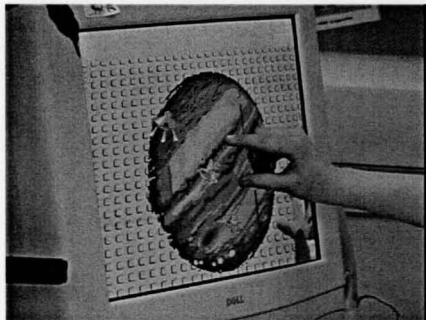
and then to the dog

wiggles pen in small circle

Or whatever.

* E takes finger off top-right stick

E



or

traces a short vertical line ('stick') on screen

no, or should we put one there

on the right side of the alien

so that,

with finger traces line on screen from alien

so that could

to the right-bottom stick

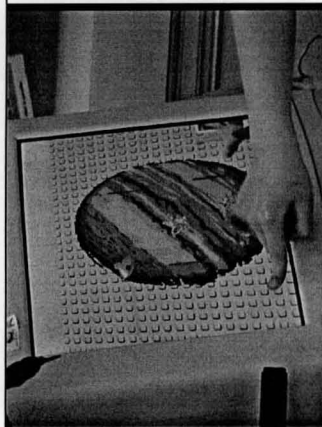
bounce to there

which could try to bounce to

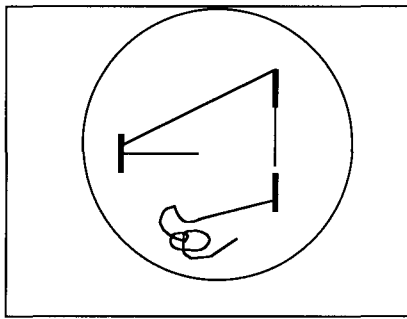
there

traces finger past the dog

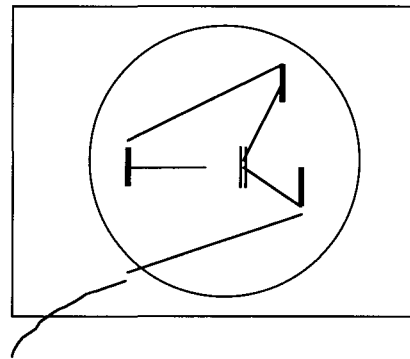
12.22



or something like that and slowly off the bottom left of the screen



Rachel



Emily

Figure 5.12 A diagram of the students' gestures with the screen

Three important points emerge from a multimodal analysis of this instance in relation to what unfolds in the session as they program the bouncing behaviour. First, the co-ordination of the two students' initial talk and gesture appears to show that they have a shared vision of how they imagine the bullet moving. However, at the point that the students stop acting in unison, two alternative versions of the movement of the bullet emerge (that they are alternative versions of events is indicated by the break in the co-ordination of their activity and Emily's use of the word 'or').

Rachel's gestures suggest that she is working with the entity 'bounce' as a generalised concept of movement as going from one place to another. Emily appears to be working with the entity 'bounce' as a specific (and more specialised) kind of movement. Holding her finger on the top-right stick can be read as a gestural sign of her realisation of 'bounce' as a particular kind of movement. Emily understands that a bullet could not move in a perpendicular line from the top-right to the bottom-right stick (as gestured by Rachel). In order to 'imagine' the movement of the bullet Emily gesturally traces an 'imagined' stick to the right of the alien. This 'gestural overlay' adds another stick to the visual design of the game which in turn enables her to imagine the bullet bouncing from the top-right stick to the bottom-right stick, and then off past the dog.

The second point to emerge from this multimodal analysis is the students' uncertainty of about what it is that 'produces' the bounce. Just as their two accounts start similarly they end similarly. Each account ends with a linguistic (spoken) vagueness, both in 'tone of voice' and in Lexis (R: 'whatever', E: 'try to' and 'or something'), and a gestured vagueness - a change of speed and non-directed gesture (R wiggles her pen, E slowly trails her finger off the edge of the screen). I suggest this realisation marks the students' uncertainty about how the movement of a bullet would come to an end if the dog is not hit by it: would the ball keep bouncing, or go off screen? This is itself an uncertainty of what is *producing the bounce* – the ball or the something that is hit by the ball.

Thirdly, the *invisibility*, the visual absence, of the bullets at this stage of the design is, I want to suggest, something that proves to be problematic for the students as they move from an imagined account of the movement of the balls to the programming of it within Toontalk.

The students' gestured overlay with the screen leads them to 'calculate' where the ball will bounce and Emily's suggestion that they need to place some horizontal sticks on the planet.

The Entity 'Bounce' within Toontalk

The students select the bounce anima-gadget from the Toontalk notebook. (The bounce anima-gadget is analysed in some detail earlier in the chapter (pages) and is shown in figure 5.6.) As discussed earlier the entity 'bounce' is represented in three modes, writing, still image, and movement. These three modal representations provide different resources for the students' construction of the entity 'bounce'. The resources of image, movement, and writing work together to define 'bouncing' within the mathematical paradigm of the system. The two students first look at the bouncing anima-gadget in the 'action-state'. They select the two spring behaviours and 'flip' them over to look at the representation of bounce in the 'edit-state'. The multimodal representation of 'bounce' on the anima-gadget specifies (and demonstrates) the multiple meanings of bounce within the Toontalk, and introduces the notion of agency. As discussed earlier, the students have not resolved the question of agency within their earlier design of the game the students' interaction with the affordances of the Toontalk now require them to do so.

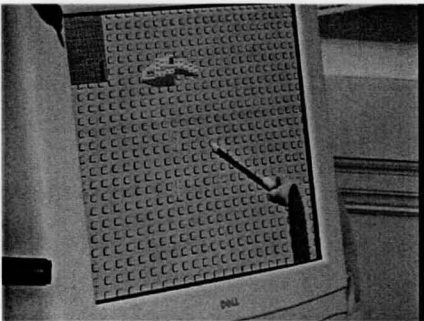
Attaching Bounce

Once they have read the anima-gadget the students start to program the bounce behaviour into their game (this is described in Transcript 5.2). First they select and copy the bounce behaviour (by copying the image of the springs). They then need to

place it on the back of an object. They decide, wrongly, to place the bounce behaviour on the sticks in the game.

In fact, in order for the game to work as the students intend it to they need to attach the bounce behaviour to the bullets. (Knowing this, the researcher persuades the students to program one stick.) In everyday terms it might be the 'sticks' that are thought to 'carry' the property of producing bounce – the sticks interrupt the movement of the bullets and in doing so 'produce' the bounce. The students are likely to have experience of a ball bouncing differently on different surfaces, from which they may deduce (correctly) that bounce is connected with a surface. I want to suggest it is the students' everyday experiences that bring the 'sticks' into the realm of programming bounce. Further, I want to suggest that the students' use of bounce in their everyday talk does not 'fit' easily with the semantic field of bullet. As shown earlier the word 'bounce' brought forth the student's transformation of the object from a bullet to a ball: bullets are hard, they do not 'have' bounce. It is this everyday understanding of bounce as a quality rather than a specific kind of movement that opens up the potential for the sticks to be what makes them bounce. This ambiguity of agency can persist in the multimodal representation of the entity bounce as a mathematical entity in the Toontalk behaviour 'action-state' (figure 5.6 a.). In the 'action-state' an image of a spring is shown moving (bouncing) between two 'bars'. When the students took the spring out of the anima-gadget notebook it moved in a straight line. Reading this behaviour from an everyday perspective it is perhaps easy to understand the thinking that led the students to program the bouncing behaviour onto the 'sticks' in their game. They assumed that the sticks produced the bounce.

Transcript 5.2: Students' initial decision of where to attach the bounce behaviour

Time	Person	Screen Grabs	Speech	Gesture with screen
12.43	E			Emily uses 'wandy' tool to copy the images of the springs –
	I		Where are you going to put <u>that</u> ?	'pointing at the sticks'
	R		on the back of the sticks	R copies a fifth spring
	I		So what will the sticks do?	
	R		So when the bullets sort of hit the sticks they'll bounce off. But we want them to.	
	E		<u>those are clones</u>	R Copies a sixth spring
	R		go diagonally	
12.44	I		okay	E point at springs on screen

Playing the Game

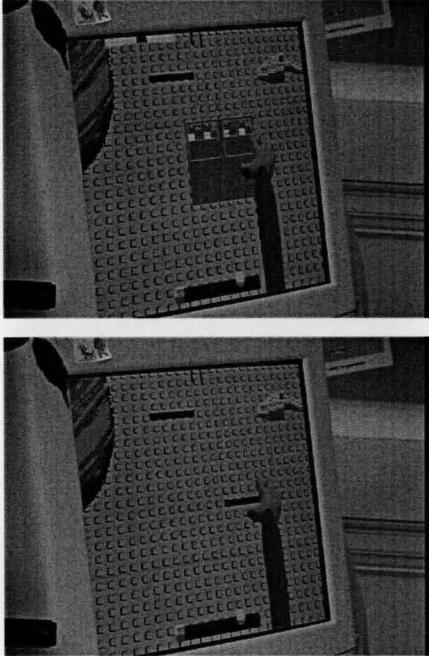
It was the visual experience of playing the game that led the students to realise their mistake and how to rectify it. In this episode (shown in transcript 5.3) the students program the sticks to bounce. They then place the sticks on the game. When they played the game the sticks bounced off. In working out ‘what happened’ the students realise that they should have programmed the bullets to bounce rather than the sticks. Through their engagement with the multimodal resources of Toontalk the students worked out their ambiguities about agency that were not challenged or required to be resolved by the design on paper through drawing/image and talk.

Making the Bullets Bounce

The students realise that in order for the game to work as they intend they need to program the bounce onto the bullets. During the next 20 minutes of the session the students play the game to clarify the problem, program the bullets, save the game, and label it in the Toontalk note-book. The bullets (as mentioned earlier) are not visible except when playing the game. Rachel asks in frustrated and plaintive tones, “Where are we going to get a bullet?”. At which point Emily realises that the bullets are ‘in’ the alien.

The programming process of finding and re-programming the bullets is shown in figure 5.13. The student flips over the alien object to find the behaviour ‘I fire in four directions’ that is attached to it. She then has to deconstruct this behaviour into its four ‘directional’ behaviours. Working with the behaviour ‘I fire a white bullet to the left when you press the left arrow’ the student selects and deconstructs elements of the code by removing the white bullet from the object box of the program code. She then flips over the white bullet object and changes the program code by adding the bounce behaviour to the bullet. Repeating these steps in reverse she reconstructs the code. The student visually interacts with the screen and physically manipulates the mouse and keys. There is little talk involved in the programming apart from the student’s spoken

Transcript 5.3 Students play game and re-think where to attach bounce behaviour

Time	Person	Screen grabs	Speech	Gesture with screen
12.46				
	E		Done it!	
	R		Oh yeah	
	I		So lets put that on now and lets <u>try it, test it out, before we do all</u> <u>the work on all the others</u> <u>okay</u>	E 'picks up' the stick and moves it across the screen to the game She positions the stick on the <u>game</u> .

R
E
I
R



12.47

As she 'lets go off' the stick the Bammer tool 'runs' onto screen and hammers the stick.

The stick bounces and moves off screen.

That wasn't supposed to go
bouncing

What happened?

What happened?

No! That's supposed to stay
STILL, and we are supposed to
put that sense on the back of the
BULLETS!

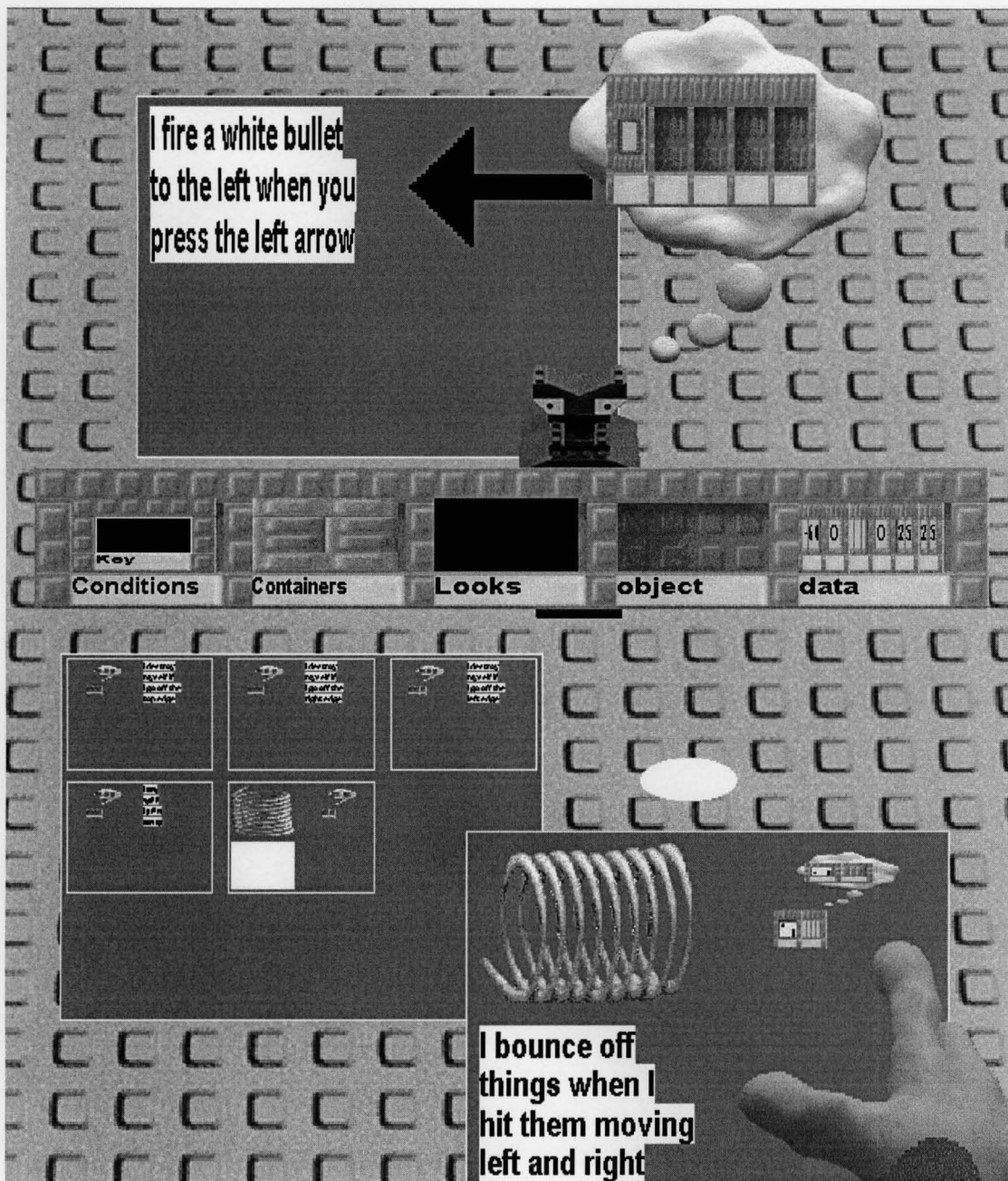


Figure 5.13 Placing the 'I bounce left and right' on the bullet that fires left

appeal to the tools of the system, ‘I need dusty, dusty, dusty, quickly dusty’ or ‘ok, F,F,F,F.’ (F is the Toontalk command to pick up and flip an object).

The researcher intervenes when the student is about to replace the bullet (with the bouncing behaviour attached) on the back of the alien object and asks her what bullet she has changed to bounce off things. The students both realise that they have to “do it on every single one”. After expressing their dismay Emily realises how they can do this quickly, “Oh I know, you can just copy the other bullet and put it on”. The students then program each of the four bullets to bounce.

The Angle of Bounce

After programming the bullets to bounce the students play the game. The intention is for the bullets to travel left, right, up and down. As the students press the arrow keys the bullets that the alien fires travel diagonally.

While playing the game the students comment on the movement of the bullets: Rachel says, “no, its supposed to go to there...the left’s supposed to go that way”. At this point Rachel returns to ‘gestural overlay’ on the screen to show the intended movement of the bullets. The researcher intervenes at this point and asks the students, “When you looked at the spring there were two behaviours on the back of it? One said I bounce up and the other said what? I go left...do you remember that? I go left”. In the exchange that follows (described in transcript 5.4) the research interviewer (indicated by I in the transcript) begins to gesture on the table in order to prompt the students to solve the problem of the movement of the bullets. She then uses pen and paper to make these gestures ‘permanent’ and to show the outcome of the simultaneous movement of the pen up and to left – that is a diagonal line. Finally the students name this direction as ‘diagonal’ and the need to re-program the game.

Transcript 5.4

Through playing the game the students realised there was a problem with the movement of the balls. The researcher prompted the students through her gesture, talk, and use of visualisation, to think about the behaviours they have put on the bullets. The researcher's gestured enactment of the movement of the bullets prompted the students to understand the movement of the bullets in the game as the product of their programming. The researcher's use of gesture which, in contrast to the students', is on paper and the table surface rather than the screen created a different kind of 'idealised space' for the game-design. That is, the researcher's gestures suggested the need to think about movement (in this case the angle of movement) outside of the Toontalk environment.

Discussion

The move from page to screen changes the modes available for meaning making. Analysis of the students' interaction with Toontalk, one another and the researcher shows that learning and mode are connected. The multimodal resources they worked with foregrounded aspects of the entity bounce in specific ways, which in turn shaped the students' construction of the entity bounce and angle.

When designing the game on paper the affordances of writing did not demand that the agency of elements be explicit. The affordances of visual communication required the game elements named in the writing to be visually defined and for the relations between them to be displayed.

The students' drawing and writing on the worksheet is design in two particular modes and not the game itself. This initial design is the student's externalisation of the notion of game in the modes of drawing and writing but this design is incited by the students' understanding of the potentials and genre expectations of Toontalk (and games for screen more generally). That is, the initial design is informed by the potentials of movement, sound-effect, 'catching', and destroying. The students' drawing is as an account of the outcome of the game – the bullet comes from the

alien, ricochets off a barrier, then off another, and hits the little figure that explodes. The affordances of mode and medium both enable and constrain the design of the game and the construction of the concept of ‘bounce’.

Even though the initial design on paper was designed with screen and Toontalk in mind, the move to design the game on screen and the multimodal resources of Toontalk demands a transformation of the students’ notion of the game modally. The students are required to move the initial design from the boundaried flat page to open multimodal and multi-dimensionality of the screen. They move from the affordances of written word and static line drawing, to the affordances of colour, ready-made images, movement, and sound effect. The students have to transform the shape of bounce /rule as written in language (and image) to the multimodal Toontalk system.

The visual design of the game narrative in Toontalk brings out the students’ ambiguities about the movement of the game elements in the second game-design session. These ambiguities are present in the paper and pen design of the game; designing the game on screen, however, the modal affordances of Toontalk – in particular the potential for movement - ‘demand’ that these ambiguities be resolved. Toontalk offers the potential to represent the movement of game elements and requires a behaviour to be attached to an object. This serves to foreground the agency of an object in the game-design process. It raises the question ‘what objects have agency’ – an issue that is present but not required to be resolved in the pen and paper game-design. In short, the modal affordances of writing, drawing and the screen demand different epistemological commitments, these are summarised in Table 5.3. As they move from page to screen the students are involved in the modal transformation of the elements (signs) that feature in the game and the entity ‘bounce’.

Table 5.3 The modal affordances and epistemological commitments in the students' written, drawn and Toontalk game designs.

Technology	Pen and Paper		Toontalk
Mode	Writing	Still image (drawing)	movement, still image, sound-effect, and colour
Epistemological commitments	<ul style="list-style-type: none"> Names the elements Tells the sequence of events Names the actional relations between elements 	<ul style="list-style-type: none"> Displays the elements Displays the relationship between elements Displays the events/actions simultaneously Constructs 'bounce' as outcome 	<ul style="list-style-type: none"> Shows the elements and their relationship to one another as movement in time and space Shows the action of the elements as a sequence in time and space Identifies the 'agents' of events Constructs 'bounce' as the conjunction of agency, movement and angle

The design of 'bounce' in the game occurred over a series of six frames of activity. The iterative move of the students between playing, planning, and programming enabled them to recognise and solve problems in the game design. Having identified a problem the students planing was multimodal, using speech, gesture, and interacting with the visual objects on the screen. Gesturing at the screen the students were able to introduce new elements and to produce their imagined game as a 'gestured overlay'. These gestures were one indicator of the students' uncertainty, for example what it is that 'produces' the bounce. At such moments of uncertainty the visual mode is crucial. If an element is not visually available it can not be easily brought into the imagined game through students' gesture and is at risk of being 'invisible' in the problem solving process.

Through their gesture in relation to the screen itself the students create a space for making meaning which enables them to bring together their everyday knowledge of bounce and the Toontalk system. This space created by the gestures of the students on the screen serves to connect the students' activity, their imagined game (the trajectory of bullet), and the Toontalk program. The space is one in which the students can display their intentions without having to engage with the constraints of the program. This space is produced through the gaze and gesture of the students and is a space focused on outcomes – like a visual/gestural blueprint. In this space the vagueness of their gestures realises their recognition of a problem.

As I discussed in the first part of this chapter the Toontalk bouncing behaviour shapes the multimodal construction of the concept bounce and the potential for what students can do with them. The students' confusion about what game element they should attach the bounce behaviour to was, as I have shown, the result of their everyday understanding (and experiences) of bounce and 'agency' and the modal affordances of the Toontalk programming system. Within this there appears to be a confusion about 'what it is that produces bounce' and 'what it is that bounces'. In other words, the students appear to understand something bouncing as a 'result' of their everyday experiences and knowledge.

In terms of mode, at this point in their game-design the students are working and designing by looking at the modes on screen – what is visible on the screen is important for the process of designing the game. The representation of the entity bounce is visual - the bounce is *in* the image of the spring and they are *looking* at the game to decide where to 'attach' the bounce. The 'sticks' (bars) are visible on screen, however, the bullets are not visible – they are only visible when the game is being played. In this visual mode of working the system did not make the bullets available as a potential object that the students could specify as the object that the 'I bounce...' refers to. In short, when working in a visual mode agency depends on visual presence.

Again, playing the game enabled the students to recognise and resolve the problem of the behaviour and agency, that the bounce behaviour needed to be attached to the bullets not the sticks. Making the bullets bounce involved the students in doing some quite complex programming. I want to suggest that the students' ease in undertaking this programming process is in part due to the merger of the game as a narrative and the multimodal affordances of Toontalk at this point in the game-design. At this stage of programming the bullet and its context in the game-narrative are visible – in other words it is the alien that fires the bullets. The visual grammar of the Toontalk system, in the form of the strip of the program boxes held by the robot, visually and lexically names the object as a bullet. This visual representation of the game narrative offers a potential to bring together the semantic field of 'bullet' and 'bounce' (bullets as game).

The angle of bounce became a problem in the construction of the game – again this problem was recognised through playing the game. The researcher's gestured enactment of the movement of the bullets prompted the students to understand the movement of the bullets in the game as the product of their programming.

The configuration and arrangement of modes in Toontalk, the *multimodal design* of the system, shaped potentials for constructing the entity bounce. Some elements were visible on screen (foregrounded) while others were not. Semantic meanings were brought to bear on the construction of the entity through the choice of words. The designed relationship between the modes of image and movement brought forth the students' different potentials for thinking about the entity bounce.

The students' engagement with the multimodal Toontalk resources serves to reshape entities, in this case the entity 'bounce'. The design of these modes within Toontalk requires students to formalise and increasingly specify the entity bounce within mathematical terms, and practices such as the estimation of angles, and problem

solving. As the modes for representing bounce increase, the entity became increasingly complex.

The multimodal affordances and design of Toontalk required the students to engage with specific kinds of imaginative work. The students' interaction with these multimodal resources brings forth new ideas for the game design, the process of engaging with these applications reshapes the students' notion (and genre) of game.

The expressions of 'movement' made available via writing in the initial design of the game are not immediately transferable in the move from page to screen. The availability of movement as a resource in Toontalk offers new potentials for representation. The modal affordances of Toontalk require the ambiguities afforded by image and writing to be resolved: How will the object move? What direction will it move in? How fast will it move? Under what conditions will it move? What object 'has' the bounce? Through the process of addressing these questions that are raised by the demands of the Toontalk system the concept of bounce is transformed from an everyday to a mathematical concept.

The multimodal resources of Toontalk serve to highlight (make salient), to specify the entity 'bounce' in mathematical terms (that is it is specified in relation to the angle of movement, direction, and agency). The affordances of the system demand that essentially mathematical questions and problems be solved in order for the game to be built, that is, in order for the narrative of the game to cohere. Through the design of the modes in Toontalk, mathematics is naturalised within the Toontalk and the students are engaged in the process of mathematics via game building.

The multimodal character of Toontalk and the semiotic features of the screen as compared with the page bring about changes in the practices of game and mathematics. The user's task is to select and order the elements of bounce that are

made available to them in order to make sense of the representation of the entity bounce on screen.

These changes can be understood as the move from a matter of interpretation to a matter of design. The students' design of the game is an outcome of the modal affordances of the resources of Toontalk, their interactions with the researcher, their everyday experiences/understanding of bounce, their original idea, and their game playing (and palpable disappointments with programming through this). Through their interaction with the spatial dimensions of the screen (a resource of Toontalk) the students create spaces for different kinds of activity. Through gesture on the screen they create an 'imagined space overlaying the screen' in which the students 'place' things where they want them and imagine their movement. This 'planning space' 'connects' the students and the Toontalk in terms of an imagined game. The students' use of the screen as a space serves to delineate between the practices involved in making a game (the practices of constructing objects and code) and those of playing a game.

Through this modal reconfiguration of potentials for meaning the learner is re-positioned from being a re-producer of knowledge to producer of knowledge. Toontalk is realised within a highly sensory animated cartoon/game genre. This enables the user to work with principles of game and via the mediating tools of the program (e.g. the robots, Wandy, Bammer) to engage with mathematical concepts. The user is engaged in the iterative work of transforming her or his understanding and experiences of the everyday into the mathematical (and vice versa) – both 'versions' of rules are enabled to 'co-exist' within the system. I suggest that the genre of computer-based learning environments brings forth (provides the potentials for) different genres of engagement with them (Jewitt, 2002).

Conclusion

The transformation of pedagogy and knowledge from page to screen offers teachers and learners access to different representational and communicational resources. Many of these are not language based. To summarise, this example shows how the designer's choice of representational mode re-mediate learning. The choice of representational mode shapes curriculum entities (in this case the entity 'bounce' and 'rule') in different ways. The representational modes and their configurations on screen also shape the learning environment itself, and the position of the learner to the object of study.

Multimodality offers a way to think about the computer as a tool that takes account of the full range of representational resources modes on screen, and the interactions with screen and other people in the learning context. Multimodality offers a way of exploring the re-mediating effect of computer mediated learning, and in turn re-thinking learning beyond language.

6. The Multimodal Construction of the School Science Entities ‘States of Matter’ and ‘Particles’ on Screen

Introduction

In this chapter I explore how the multimodal resources of the computer screen reshape the science curriculum entity ‘states of matter’. In particular, I focus on how these resources result in a shift from the traditional focus on distinct ‘states of matter’ to a new representation of the process of the transformation from one state of matter to another. Alongside this I examine how these resources re-mediate the practices of students in the science classroom and their agency in the production and construction of knowledge. Throughout the chapter I draw on an illustrative example of a science lesson with a year seven class in which the CD-ROM *Multimedia Science School* (2001) is used to investigate the topic ‘states of matter’.

‘States of Matter’ and the Science Curriculum

Developing an understanding of ‘states of matter’ and ‘particles’ is central to the school science curriculum at Key Stage 3 (Dfee, 1999). This is a part of the more general curriculum requirement to “understand materials and their properties” and the “use of scientific ideas and models to explain phenomena and events”. In particular the curriculum requires students to “know an example of solid, liquid and gas”, to “describe the arrangement of ‘particles’ in each of these three states” and to understand “the impact of heating and cooling on states of matter”. More generally, the curriculum highlights the need for students to be able to ‘make and test predictions’ and to make relevant observations. Students are expected to ‘make use of their existing knowledge and understanding in science’ and to be able to “interpret and explain their results”. In addition the curriculum states that students should be able to “use a range of methods to represent and communicate data” including

diagrams and graphs. Students are required to use these representations to “describe patterns or relationships in data” and to draw scientific conclusions.

The national curriculum objectives that are outlined above inform the science lesson on ‘states of matter’ analysed in this chapter but do so in particular ways, ways which differ in relation to the technology used to mediate the curriculum. Throughout the lesson the students use the multimedia package *Multimedia Science School* to investigate particle arrangements in a solid, a liquid and a gas and to explore the changes in particle arrangement that occur with heating and cooling. The lesson is divided into two parts, in the first part the students work at individual computers using a worksheet prepared by the teacher, and in the second part the students work with an interactive whiteboard to present their ideas to the whole class for discussion.

In the following section I discuss the ways in which the entities ‘states of matter’ and ‘particles’ have been taught traditionally in the science classroom without new technologies.

The Representation of ‘States of Matter’ on Page and in the Classroom

‘Particles’ and ‘states of matter’ are represented in the majority of School Science textbooks in two main ways: either in the form of diagrams (e.g. figure 6.1) or in the form of photographic images. The former kind of image serves to classify ‘states of matter’ in terms of their arrangement, the density of ‘particles’, and the spacing of ‘particles’. The latter type of image represents everyday examples of ‘states of matter’ in a ‘realistic form’ (e.g. figure 6.2). These images tend to offer representations of the ‘states of matter’ that draw on children’s everyday experience of materials- usually ice, water, and steam. Teachers offer ‘canonical’ images of ‘states of matter’ similar to these in the classroom. Here I draw briefly on work with colleagues on the multimodal production of school science (Jewitt and Kress, 2002) which analyses the multimodal construction of ‘states of matter’ in a lesson with year eight students. In order to represent and communicate the entity ‘particles’ the

teacher, in a lesson with year eight students initially drew an image on the blackboard (see figure 6.3)ⁱ. This image, like typical textbook images, represents the arrangement of the ‘particles’ in each state, a solid, a liquid, and a gas.

As a result of the modal affordances and constraints of still images, images cannot readily realise the movement of the ‘particles’: teachers and textbook illustrators who work with images on the ‘page’ have to resort to the use of arrows and cartoon symbols to indicate movement. The curriculum focus is on the arrangement and behaviour of ‘particles’ in discrete and specific ‘states of matter’, rather than on the process of transformation from one state to another. This focus is easily realised and brought forth by the spatial and compositional resources of the mode of still image.

In the context of the classroom the teacher can do rhetorical work to animate the entity ‘particles’ through the dynamic potential of gesture and movement, and in speech to ‘lexicalize’ (name) movement in particular ways. This serves to bring the entity ‘particles’ ‘to life’ so to speak: to ‘animate’ them. Earlier work with colleagues has shown how teachers enact a series of ‘imagined demonstrations’ to bring entities that are not usually visible into existence (Kress et. al, 2001). The teacher’s shift between modes in the classroom also represented a shift in the cognitive possibilities and demands on the learner. In this way the teacher’s action, gesture, image, and speech interweave rhetorically to convey meaning, to shape students’ views of the world, in complex ways which language alone cannot realise. In the classroom described above, the main work of the teacher is to give the students the resources with which they can construct the ‘invisible’, the arrangement and movement of the ‘particles’, to provide the students with a visual scientific overlay for their everyday view.

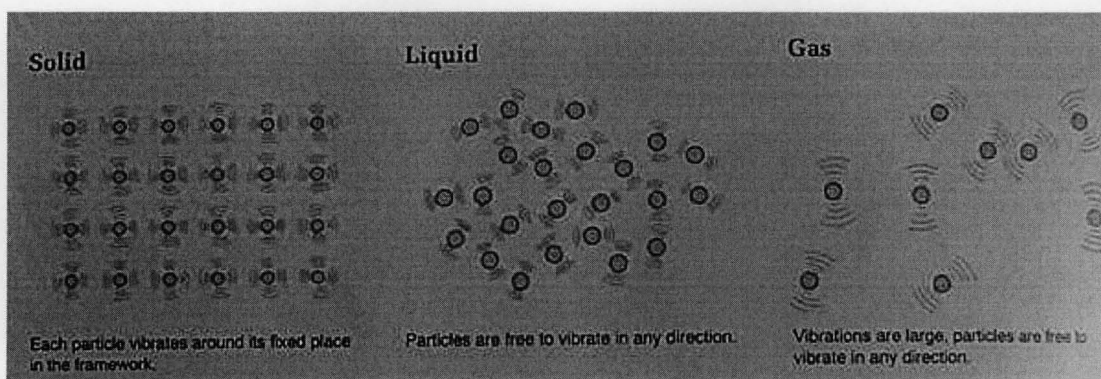


Figure 6.1 Textbook representation of 'Particles' and 'states of matter' in the form of diagrams (Starting Science (1996) Oxford University Press)

	SOLID	LIQUID	GAS
	ice 	water 	steam
ARRANGEMENT of particles	Particles are in a fixed framework	Particles are free to move in the liquid	Particles are free to move anywhere
NUMBER of particles	Many particles in a certain volume	Many particles in a certain volume	Few particles in a certain volume
SPACING of particles	Particles are close together	Particles are close together	Particles are far apart
FORCES between particles	Forces between particles are very strong	Forces between particles are strong	Forces between particles are very weak

Figure 6.2 Textbook representation of 'Particles' and 'states of matter' in the form of photographic images (Starting Science (1996) Oxford University Press)

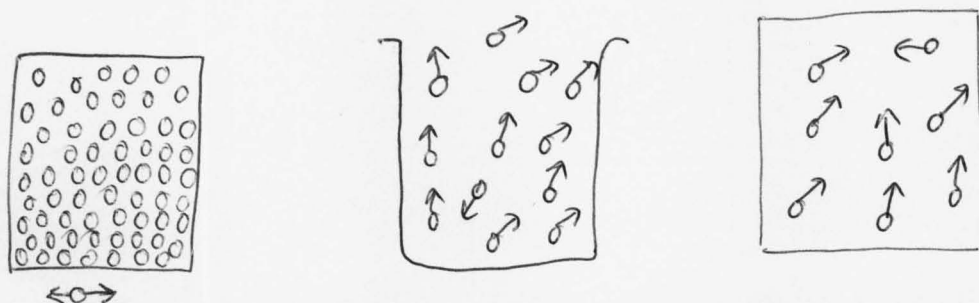


Figure 6.3 A Teacher's typical drawing on the arrangement of the 'particles' in each state, a solid, a liquid, and a gas

In this chapter I explore what happens when, in the move from page to screen, the modal resources of animation and colour are made available in the construction of the curriculum entities ‘particle’ and ‘states of matter’. A central question in this chapter is ‘what happens when the central work of the teacher and the students shifts from one of visualising the ‘particles’ in their arrangements in one of the three states, to observing them in their transition from state to state?’; that is, in the shift from arrangement as state to the ‘process of transformation’?’.

In the following section I describe the multimodal resources that *Multimedia Science School* (2001) makes available in the classroom and analyse how these shape the curriculum entities ‘states of matter’, ‘particles’, ‘solid’, ‘liquid’ and ‘gas’. I then discuss how the teacher and students worked with these resources, and the ways in which their practices and roles were transformed through their interaction with the resources and the facilities of the medium.

The CD-ROM, Screen and its Characteristics

Multimedia Science School (2001) covers a range of curriculum topic areas including ‘states of matter’. Each ‘state’ is represented as a ‘button’ on the left panel of the screen. When a topic is selected, a series of keys are displayed detailing the contents of the topic. Selecting one of these content keys activates a multimodal sequence using the modes of image, colour and movement (called a ‘slide-show’ within the application) which is displayed in the central ‘screen-within a screen’.

When the topic ‘states of matter’ is selected, a series of keys showing the ‘content’ of the topic are displayed on a panel on the right side of the screen (prior to this selection these keys are not displayed). These keys relate to transformations from one state of matter to another, or to be more specific, from ‘solid to liquid’, ‘liquid to gas’, ‘gas to liquid’, ‘liquid to solid’ and ‘sublimation’. (I do not discuss the CD-ROM representation of ‘Sublimation’ as it is not an area that the students investigated.)

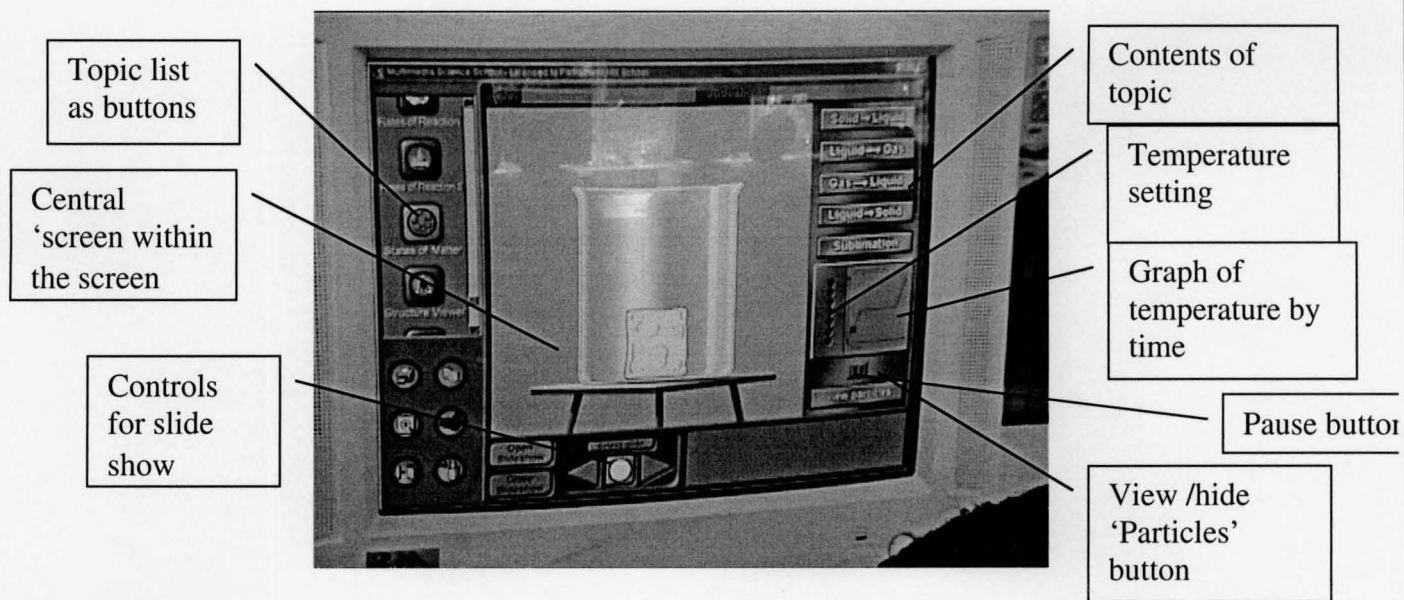


Figure 6.4: The opening 'Hide Particles' option screen of the topic 'states of matter' in *Multimedia Science School*.



Figure 6.5 The opening 'View Particles' option screen of the topic 'states of matter' in *Multimedia Science School*.

In the lesson analysed in this chapter, the task of the students is to use the representation of the CD-ROM to predict what might happen when a solid, a liquid or a gas is heated or cooled. Alongside this the students investigate the arrangement and behaviour of the 'particles' on cooling and heating. The CD-ROM offers the students the potential to 'pause' the representations of the transformations, and to move easily and quickly between the two viewing options (with or without 'particles') and the different 'states of matter'.

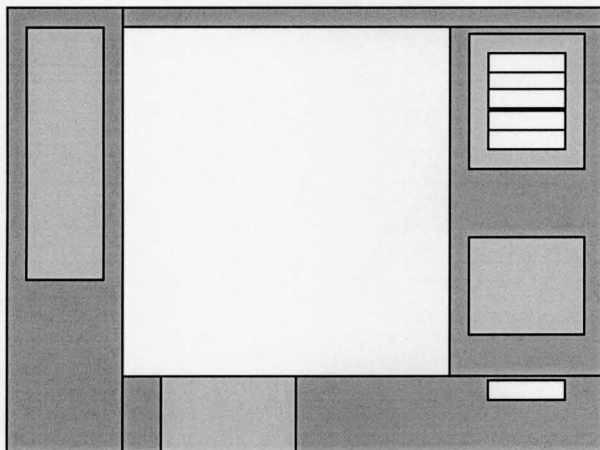
The interface of *Multimedia Science School* draws on the modes of writing, image, movement, and their arrangement on screen; in other words, it is multimodal. The way that these modes are organised visually (designed) on the screen serves to create two distinct areas of the screen: a 'frame' and a 'screen within the screen'. Although the 'frame' is slightly larger than the 'screen within the screen' (the 'frame' occupies 55% of the screen space as compared with the 'screen within the screen' that occupies 45% of it) due to its centrality, the latter dominates the screen. These two areas of the screen attend to quite distinct kinds of activity. The 'frame' attends to scientific classification and labelling and presents the means by which scientific phenomena such as 'states of matter' can be explored. The 'screen within the screen' attends to the empirical world that is to be the subject of scientific investigation that is made visible on the screen. These two aspects of school science – scientific theory and the empirical world, are marked through the visual composition of the screen, as well as modally. The 'frame' relies on the mode of writing and the visual resources of layout and composition while the 'screen-within a screen' relies on the modes of image and movement. Both employ the mode of colour; however they do so in quite different ways. In the following section I describe the designed arrangement of modal resources in the 'frame' and in the central screen and discuss how each contributes differently to the construction of the entities of the science curriculum, and to learning more generally.

The Elements of the Screen: The ‘Frame’

The ‘frame’ around the ‘screen within the screen’ provides a variety of means by which the display in the central screen can be changed. It includes three panels with keys or buttons displayed on each of these panels, which relate to the content of the screen (see figure 6.4). The three elements of the ‘frame’ discussed below are the ‘topic keys’ on the left panel, and the ‘content keys’, the ‘hide/view particle key’ and the graph displayed on the right-hand panel.

Colour is used to distinguish between the ‘frame’ and the ‘screen within the screen’. The colours used in the ‘frame’ are muted and dark and use several shades of grey. These colours are dense and flat. This use of colour serves as a sign of the ‘weight’ and the ‘seriousness’ of the ‘frame’ and to locate it within the coding orientation of ‘scientificness’. Regardless of the menu topic that is chosen, the ‘frame’ remains the same. The visual permanence of the ‘frame’, together with this use of colour, is a sign of its authority. The lack of saturated colour in the ‘frame’ serves to neutralise and background it and it serves to draw attention away from it. The grey tones of machinery, the panels of buttons and keys, and the flatness of its texture combine to present the ‘frame’, and more broadly speaking the science that it represents, as a kind of ‘technology of control’.

The elements included in the ‘frame’ are ‘stripped back’ to the essential detail of their technical function, and to nothing more. These elements are displayed in conventional scientific forms, as ‘graph’ and ‘labels’, and with a focus on classification. Overall, the outer ‘frame’ of the screen (represented in figure 6.6 in grey-scale) quite literally provides a ‘frame’ for the activity displayed in the central screen-within-a-screen. It indicates ‘what is to be attended to’ by the student.



6.6 The outer 'frame' of the screen represented in grey scale

Writing (as Captions)

The panels on the left and the right of the frame display a series of 'buttons', each of which has a written 'label'. The buttons on the panel on the left represent the categories of the National Curriculum topic areas that are covered by the CD-ROM, such as, in this case, 'states of matter'. These buttons are displayed as a vertical arrangement of square icons, in alphabetical order. The principle for the compositional order of these keys is their classification in relation to the process of heating and cooling. The first two transformations (solid to liquid and liquid to gas) are concerned with heating, while the second two (gas to liquid and liquid to solid) are concerned with cooling.

The button for 'states of matter' consists of a circle within a square, and inside the circle is an image of 'particles', underneath which are the words 'states of matter'. In this way the button visually marks 'particles' as the criterial aspect of 'states of matter'. Selecting the button 'states of matter' results in five keys being displayed on the panel on the right. These keys represent the five transformations of 'states of matter' (e.g. solid to liquid, liquid to gas, gas to liquid, liquid to solid and sublimation). In other words, each curriculum topic area available on the CD-ROM

is related to a series of keys that indicate the central areas for the investigation of the topic within the CD-ROM. These are displayed as a set of rectangular 'buttons' in a vertical list. When a button is selected it is highlighted in yellow, as a sign of its active state. Each of these 'buttons' relies on the mode of writing and acts as a written 'caption'— a kind of 'label', for the entities visually displayed in the central 'screen within the screen'.

The 'Hide Particles' and 'View Particles' Viewing Option

A 'Hide Particles' or 'View Particles' button is displayed on the right-hand panel. This key is the means by which students can switch the displayed appearance of the sequence in the central screen (each display is described in more detail later in the chapter). The viewing option 'Hide Particles' displays an 'everyday' view of the transformation of 'states of matter'. Here the focus is on 'what is' and 'how things are' in the world of the everyday, focusing on the change in shape, 'texture' and movement from one state to another, for example, from a solid to a liquid. By contrast, the option 'View Particles' displays a view beyond and beneath the everyday: a scientific view, in which the focus is on explanation 'How things actually are'. The multimodal representation of the 'Particles', their visual presence and in particular their movement serves to display the 'motivation' for the changes that can be seen in the shape and the texture of the material. They also enable the students to move between the two accounts of 'states of matter' (solid, liquid, and gas), that is, the everyday and the scientific.

The facilities of the CD-ROM enable the students to 'Pause' the moving representations, and to observe the changes in the transformation between the states. The potential to move between the two representations of the states and the specific states produces a tension between the two views in which each representation 'visually explains the other' to produce a plausible account of the phenomena.

Graph and Directionality

A small graph situated on the right panel of the 'frame' beneath the panel of keys records the effect of their interactivity with the temperature setting and the display in the 'screen within the screen'. The graph shows a plotted line with a red 'X' marked on it. The student can 'raise' or 'lower' the temperature by selecting the circular indicators of units of temperature, in the form of small buttons, to the left of the graph. For instance in the case of the change from solid to liquid an ice-cube is represented as melting, and the 'X' moves to the right and up the plotted line to indicate a rise in temperature. These 'units of temperature' are presented visually as a series of circular dots and offer a visual potential for the comparison between the four 'states of matter'. The graph introduces 'directionality' as a semiotic resource that the students need in order to be able to read and understand the process of transformation between 'states of matter'. A line visually represents an increase in temperature from the left-bottom of the graph to the top right, and a line represents a decrease from the top-left to the bottom-right. The link between heat and movement in time is made visually by the graph; it links the action of the student (clicking) and the display in the central screen. Finally, the graph draws attention to the key factor in changes in 'states of matter', that is temperature, heating and cooling.

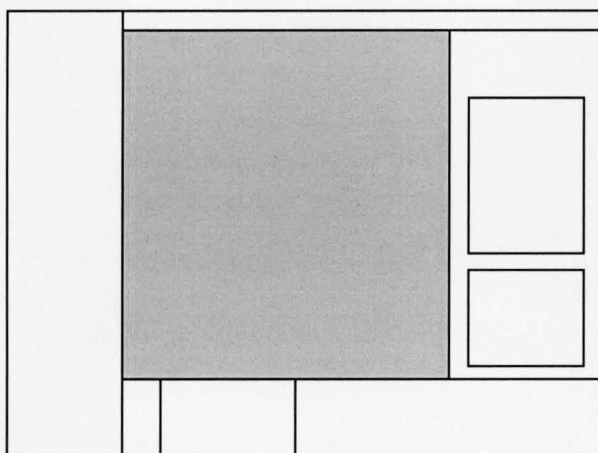
The Elements of the Screen: The 'Screen within the Screen'

The 'screen within the screen' (shown in grey-scale in figure 6.7) is an area of display. The modes of image, colour and movement are combined to display the transformation from one state of matter to another.

The range of colours used in the central screen stand in stark contrast to the dull monotone of the 'frame'. In the central screen colour is used to construct a 'hyper-scientific realism' where how things are in the 'natural' everyday world is echoed and filtered through the lens of 'scientificness - in which water is blue and ice is pale – but bluer and paler than in a naturalistic representation. The 'screen within the screen'

uses saturated colours and a range of different hues. The central screen is a multimodal space without written elements. Further in contrast to the persistence and stability of the 'frame', the central screen is a place of change and movement.

The empirical world displayed in the central screen mediates and provides the evidence that 'fills-in' the scientific concepts realised linguistically in the 'frame', in this case 'states of matter'.



6.7 The 'screen within the screen' shown in grey-scale

In order to analyse and discuss how the modes of image, colour and movement are rhetorically orchestrated to construct 'states of matter' I focus on the default starting point, that is the transformation from a solid to a liquid. The representation of the transformation from a solid to a liquid is typical of the CD-ROM's use of the modal resources of image, colour and movement in the central screen.

The Construction of the Entity 'States of Matter' on the Screen

The written elements of the 'frame' represent each 'state' in the form of scientific notation; for instance the notation 'solid -> liquid' is used rather than the everyday term 'melting'. The visual representations of 'states of matter' that are displayed in the 'screen within the screen' serve to 'fill-in' the written terms with meaning. These

visual representations bridge the potential (conceptual) gap between the students' everyday knowledge on the one hand and their experience of the phenomena displayed in the screen within the screen and the scientific explanation (and terms) offered by the written elements of the 'frame' on the other. This, I want to argue, brings about a shift in the representation of the curriculum from one of a focus on discrete states to one of focus on the transition of 'states of matter'. This curriculum shift is represented both in the written 'captions' offered by the keys and in the representations on the 'screen within the screen'.

The move from the facilities of the page to the facilities of the screen brings with it the potential to 'overlay' images and to represent the movement of the 'particles'. As I mentioned earlier, the shift in the facilities of the medium and the introduction of the resources of the mode of movement change the curriculum focus from the conceptual representation of discrete 'states of matter' to the dynamic construction of the transformations between 'states of matter'. The conceptual image of discrete 'states of matter' becomes one part of a detailed dynamic representation of the process of change from one state to another.

The CD-ROM offers the students the potential to observe this process of transformation from two different theoretical perspectives that are realised in two different multimodal representations. First, as it is the default option, there is a traditional scientifically framed view of 'solid', 'liquid' and 'gas' in the 'everyday' world via the 'Hide Particles' viewing option. This is a realisation of the everyday view of 'states of matter' in which the 'everyday' is the naturalised view of the phenomena. The second option has to be actively selected by the student; the 'View Particles' option shows the arrangement and movement of the 'particles' in each state.

From a Solid to a Liquid

The opening screen of the 'solid to liquid' sequence shows an ice cube in a beaker set on top of a tripod stand in the central screen.

'Hide Particles' Viewing Option

The image described below is the first in a series of seven that represent the stages in the transformation from a solid to a liquid in the 'Hide Particles' viewing option, three of the images in the series are represented in figure 6.8.

The solid is specified in the image as an ice cube – an everyday example of a solid which enables the students to bring their everyday knowledge and experience of the transformation of a solid to a liquid to their learning. The modal affordances of still image demand that a specific solid is represented. The ice-cube is represented as a flat abstracted square shape, at the same time its outline is drawn roughly and includes thin lined textures. The ice cube is coloured a pale blue. The representation of the beaker stands someway between a 'cutaway' image – showing the thickness of the glass beaker, and an image using naturalistic perspective in the form of shadows and reflections of light on the beaker surface. A naturalistic representation (as shown in figure 6.4) using light and shadow in the representation of the tripod. However, the proportions of the ice cube, the tripod and the beaker are not naturalistic: if the proportion of the ice cube and the beaker were correct the tripod would have to be significantly smaller than it would be in 'reality'. Proportion is a visual resource that is used to foreground the image of the ice-cube and to visually signal that it is that which the students need to attend to.

The diagonal lines of the tripod are visual vectors (see Chapter 3) that 'act on' the beaker and its contents. The visual vectors represent the ice as a passive object that changes due to the actions of an external force. The presence of these vectors indicates that the image is a narrative one in which the 'tripod' acts on the ice. I suggest that by its 'provenance' the tripod in the image stands for 'heating' and

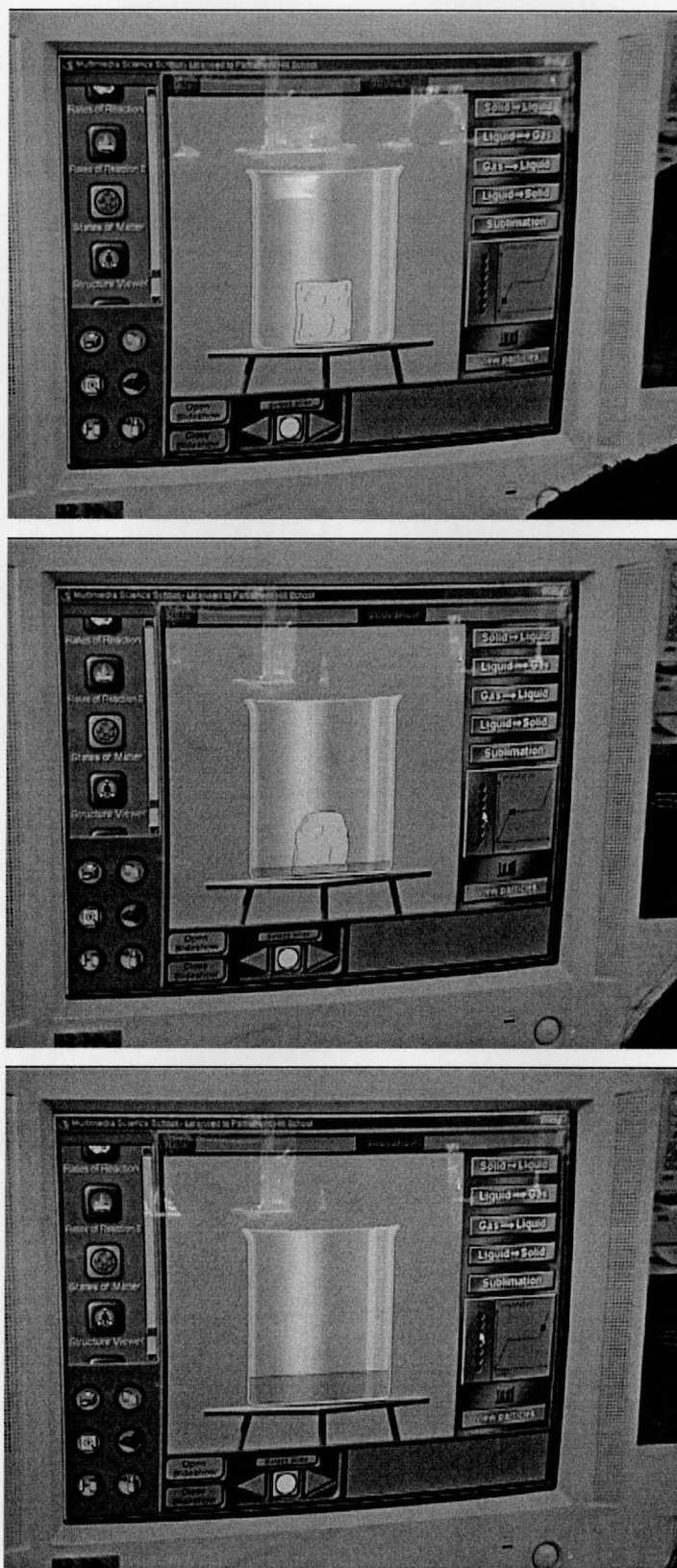


Figure 6.8 The stages in the transformation from solid to liquid, with the 'Hide Particles' viewing option.

‘cooling’, or perhaps, less specifically, for ‘change’ or ‘action’. The tripod is, however, theoretically and technically superfluous: the ice is ‘heated’ by the room temperature - there is no Bunsen burner. The representation of the tripod is an instance of the traditional means of representation (because of the traditional canonical means of conducting the experiment) lingering into the new representation. (Indeed perhaps the presence of the tripod is visual evidence of the persistent character of the ‘old’ and ‘tradition’ as it persists more strongly on the screen than it would on the laboratory bench.) The display of the equipment serves to visually position the students in front of the experiment as agents in the transformation of a solid to a liquid. The equipment places the observation clearly within the domain of science and serves visually to link the states and suggest the potential (and the need) to compare them.

As I will show later in this chapter in relation to the use of the CD-ROM and the interactive whiteboard, the student and teacher interaction with the displayed equipment serves to locate the screen in the past histories of the classroom. Through his talk and his gesture with the screen the teacher works with the student to construct the ‘experiment’ that is displayed on the screen as something that he has ‘set up’ and to ‘make it real’. In doing so, the teacher attempts to locate the display on the screen within the traditional practices of the science classroom.

The visual elements displayed on the screen are set against a flat plain pale green background that serves to de-contextualise the image. The image offers a flat on (frontal horizontal angle) view of the ice cube, in relation to which the viewer is visually positioned at eye-level. At the same time the viewer is visually positioned, through the use of vertical angle, as looking down slightly on the tripod/stand – as visually ‘powerful’ and therefore with the potential to act.

The focus on a specific example of a solid, together with the visual resources of 'attitude' (horizontal and vertical angle), contextualisation, illumination, perspective, and proportion, combine to realise an orientation to knowledge that draws on both the realism of scientific/technical orientation and naturalistic realism. In short the CD-ROM draws on the realism of the student's everyday world at the same time as inducting them into the perspective of science. The tension between the perspective of the 'frame' and the central screen is a 'place' where the ambiguities of students' learning can reside.

As the student selects a unit of temperature the image displayed in the 'screen within the screen' is changed to correspond with a representation of the effect of that degree of heating on the ice-cube. In the 'Hide Particles' viewing option a change in the state of matter is realised visually through the three semiotic resources of shape, texture and colour. The change in state from a solid to a liquid is represented via a change in shape from a cube, to a mound, to a flat surface that takes the shape of the container. The change in state of matter is represented in the change of texture from 'rough' to 'smooth'. It is realised in a change of the hue and saturation of colour, from a pale blue-white to a darker blue.

While the 'Hide Particles' viewing option offers a specific example of each state of matter, the written labels (highlighted on the keys in the upper-right side of the screen) remain at the generalised level of 'solid', 'liquid' and 'gas'. In other words the visual resources of the 'screen within the screen' (including the modes of image, colour, and movement) present an everyday view of 'particles' while the written resources of the 'frame' provide a generalised scientific one. This generalised theoretical view of 'states of matter' is realised visually (through image, colour and movement) when the 'View Particles' button is selected.

‘View Particles’ Viewing Option

Selecting the ‘View Particles’ button displays the arrangement of the ‘particles’ in the state of matter (see figure 6.9). The ‘particles’ are represented as small circular blue balls. In each instance the images of the ‘particles’ are identical and this enables the visual comparison between screens to show that what is changing is the spatial arrangement and the speed and freedom of movement of the ‘particles’ and not the characteristics of ‘particles’, for instance. The opening image of the sequences offer the traditional ‘canonical’ visual representation of a ‘solid’, a ‘liquid’ and a ‘gas’, which displays the spatial arrangement of the ‘particles’. In the CD-ROM *Multimedia Science School* the process of the weakening of the bonds between the ‘particles’, and ‘moving away’ from one another is represented through movement in terms both of the speed of the ‘particles’, and the increased space between ‘particles’ in a liquid as compared with a solid. The representation of ‘states of matter’ in the ‘View Particles’ option offers a visual explanation of the motivation for the change between ‘states of matter’ seen in the ‘Hide Particles’ viewing option. As the student ‘changes the temperature’ the representation of the state of matter changes and the particle arrangement is displayed, in other words the ‘View Particles’ option visually depicts the motivation for the phenomena.

When the ‘View Particles’ viewing option is selected, the specific example of a solid (the ice cube) is overlaid by a representation of the spatial arrangement of ‘particles’. At this point, the image of the specific solid is ‘replaced’ with an image realising a solid as a generalised theoretical solid in which the theoretical focus is on the spatial arrangement of the ‘particles’. The presence of both images on the same screen brings together the everyday view and the scientific view. The tension between these two different views of the same object creates a visual ambiguity - a gap in which the students’ uncertainties can reside: are the ‘particles’ a part of a solid? Are the ‘particles’ ‘inside’ the solid? Do the ‘particles’ and the representation of the ice cube represent the ‘same thing’? This ambiguity emerges in the students’ discussion of the ‘states of matter’ when using the CD-ROM.

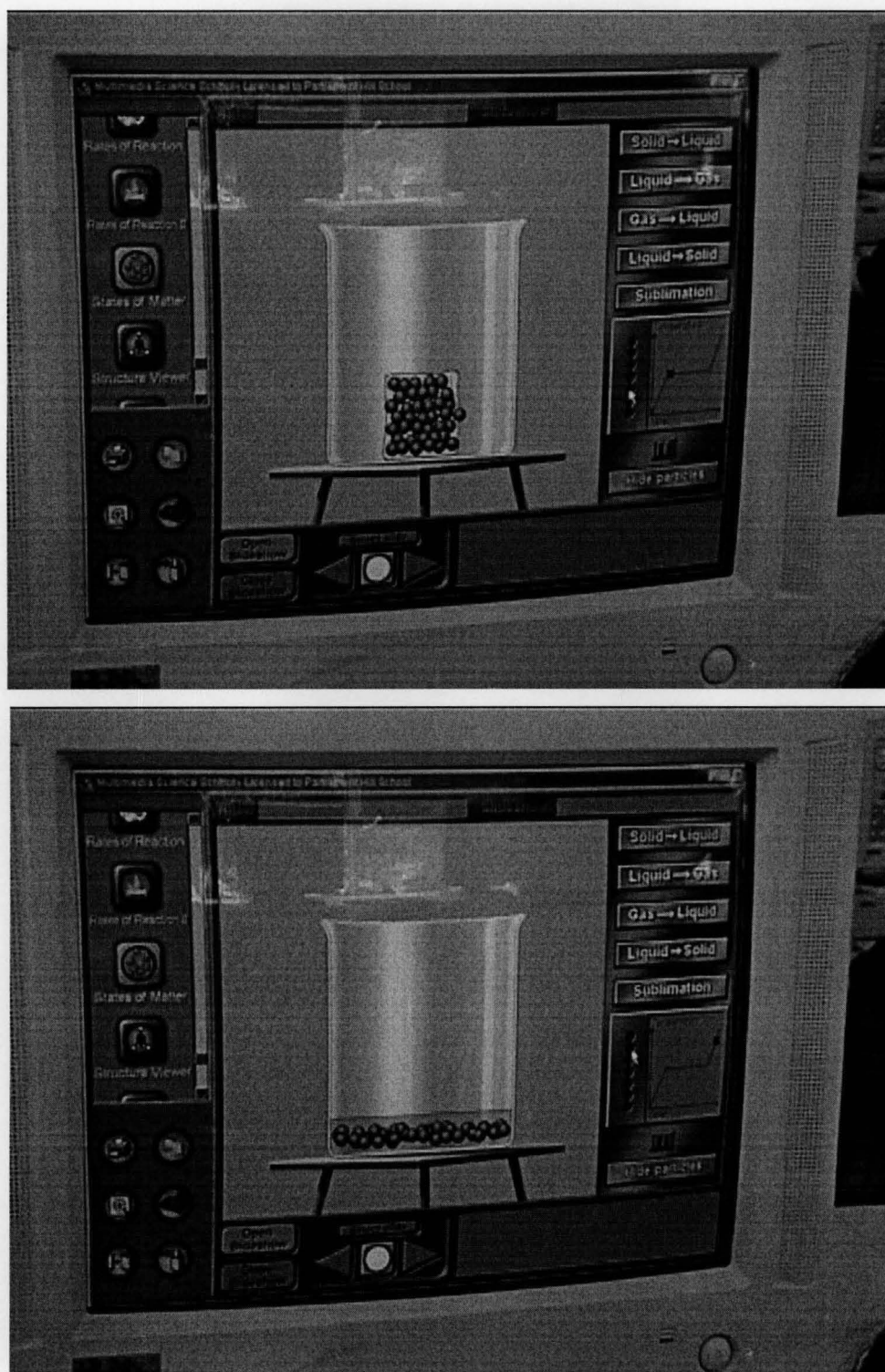


Figure 6.9 The transformation from a solid to a liquid, with the 'View Particles' option.

The same modal resources as those that are described above are used to display all of the 'states of matter' in the CD-ROM, for this reason I will not describe each one here further. Some of the specific ensembles of writing, image, colour and movement as they are displayed on the screen to realise each states are discussed in the following section where the focus is on the students' engagement with the resources of the screen.

The Engagement of the Students with the Resources of the CD-ROM

The focus in this section is on how the students engaged with the resources of the CD-ROM and on the 'gap' between what is designed in the CD-ROM, and the students' reading of these resources and their design. The students' use of the CD-ROM is organised in two different ways in the lesson. In the first part of the lesson the students work through the CD-ROM on individual computers, and later in the lesson they use an Interactive Whiteboard to present and discuss their ideas to the class. Initially I focus on the different ways that four of the students engage with the resources of the screen and interact with one another when working on separate computers. I then go on to discuss the students' engagement with the CD-ROM in a whole class presentation using the interactive whiteboard. In both instances I comment on how the resources of the screen and their organisation in this lesson reshape the role of teacher and students in the science classroom.

The Students 'Individual' Work with the CD-ROM

In the first part of the lesson the students work on separate computers to investigate 'states of matter' and the transformation from a solid to a liquid, a liquid to a gas, a gas to a liquid and a liquid to a solid. The teacher mediates the students' engagement with the CD-ROM through a worksheet. The worksheet instructs them to observe each transformation in the 'Hide Particles' viewing option and to predict what will happen when the temperature is raised or lowered. It then instructs them to select the

‘View Particles’ option, to observe the transformations and ‘to describe the change by describing what happens to the ‘particles’. The worksheet guides the students’ observation, for example, in the change from a solid to a liquid, the worksheet includes the following questions: ‘how are the ‘particles’ arranged in the solid? Are they completely still?’ and ‘Once the solid has melted what are you left with? How are the ‘particles’ arranged now? How is this different to their arrangement before?’. Despite the relatively closed structure of the material presented on the CD-ROM (the CD-ROM is structured into discrete curriculum units and specific aspects within each of these units), and the structured worksheet used, the students work with the screen in different ways.

The Resources of Image and Colour on the Screen

The modal resources of image and colour as they appear on the screen provide the students with a construction of the entities ‘states of matter’ (solid, liquid and gas) and the ‘View Particles’ viewing option presents the entity ‘particles’ the phenomenon to be explored. The ‘Hide Particles’ viewing option displays these entities from the perspective of the ‘everyday’ world, and the ‘View Particles’ option displays the scientific view of what is not usually visible – the presence and spatial arrangement of the ‘particles’ in ‘states of matter’. The visual is presented as evidence and presents the criterial aspects of what is to be understood; the work of the student is to ‘read’, that is, to interpret the meaning of these. The task of ‘reading’ these visual signs requires the students to understand what they should attend to and to select what elements in the visual representation are ‘relevant’ and ‘important’. Analysis of the students’ engagement with the visual resources of the CD-ROM as they are displayed on the screen shows the teacher that the students are actively engaged in this task. It also shows that at some points the visual resources of colour, texture and shape stand in conflict with the students’ everyday reading of the visual and that for some students this tension causes some confusion in their reading and construction of the entities.

In the case of the transformation from a Solid to a Liquid, for example, the visual resources of the screen provide the students with a representation of the arrangement of the ‘particles’ in a solid and a liquid. As the students’ comments below show, the students’ interpretation of the relationship between the ‘particles’ and the background representation of the water leads them, however, to see the ‘particles’ as being ‘a part of’ a liquid rather than to understanding the ‘particles’ as an alternative representation of a liquid. (The transcripts in this chapter include punctuation to draw attention to the hesitation, re-phrasing and reformulation of the students and the teacher, as these contribute to their work of constructing the entities in the lesson. A comma is used to indicate a short pause, and a full stop is used to indicate a longer pause, and an exclamation mark is used to indicate a high volume and pitch of voice.)

Lucy: You’ve raised the temperature so the particles form into a liquid. The particles now have more space to move freely

Kylie: So they can move more?

Lucy: Yeah they can move more freely, ‘cos in a solid they’re tightly compacted, so in a liquid they’ve got so much more space to move, ‘cos its all like jelly.

The student, Lucy, sees the ‘particles’, as ‘held in the water’ like jelly rather than representing the water itself. This student’s reading does not distinguish between the visual resources of background or foreground (overlay) and as a result her construction of the entity ‘particle’ is of something that ‘exists within’ a liquid, a solid or a gas rather than the thing that constitutes it.

The visual representation of the transformation from ‘a gas to a liquid’ in the ‘View Particles’ option raises the question of what is to be attended to for several of the students that I observed working with the CD-ROM. The representation shows gas ‘Particles’ ‘coming off’ of a saucepan of boiling water (in which the ‘particles’ are not shown); these ‘particles’ collect on the underside of the saucepan lid and form

into clusters (drops of water) and fall back into the pan of boiling water. The ‘particles’ are not shown in the boiling water; that is shown as having ‘bubbles’ in it. Several students made comments like the following one that a student, Kylie, wrote on her worksheet:

I have decreased the temperature and the particles go up singularly but come down in clusters.

This observation focuses on the number of ‘particles’ and directionality; while the observation is accurate, the student’s comment highlights a difference to the point at hand, that is, that the single ‘particle’ represents ‘a gas’ and that the ‘clusters’ represent a liquid. That is the word ‘particle’ is used to signify ‘molecule’ in a gas and ‘droplet’ in water. The representation serves to foreground the transformation that is to be attended to – the transformation from a gas to a liquid. The transformation of a liquid to a gas is represented by the use of a bubble texture which ‘stands for’ ‘a kind of particle’. This representation of ‘Particle’ is problematic as in the attempt to foreground the transformation of a gas to a liquid the representation visually separates the gas ‘particles’ from the boiling water. As a result some students ‘read’ the particle rising from the water as ‘steam coming up *through* the water’ reading the particle and the bubble texture of the water as visually separate entities. This separation serves to construct gas and liquid ‘particles’ as different kinds of ‘particles’, rather than as different arrangements of ‘particles’: as such the move from a specific representation of a ‘liquid’ to a generalised one of ‘states of matter’ and ‘transformation’ is difficult for these students to realise.

Within the CD-ROM it is the visual representation of the transformation from a liquid to a solid that appeared to be most problematic for some of the students to ‘read’ and to make sense of. The difficulty these students found in ‘reading’ this image is, I want to suggest, a consequence of the designers’ of the CD-ROM’s use of the modal resources of colour, texture and shape, clashing with the students’ principles for

understanding these resources. In one instance, two students (Lucy and Kylie) are each working at their own computer, and talking about what is displayed on screen; they select the 'liquid to gas' key. One student is working in the 'Hide Particles' viewing option and the other has selected the 'View Particles' option. The opening screen (shown in figure 6.10) shows a beaker inside another beaker: the outer one contains ice and the inner one contains water. The water is represented in a pale-blue-white colour with reflective qualities.

The students are prompted by the worksheet to answer the following question: 'What liquid can you see in the picture?' In response to the question, the students do not stay with the opening screen but click on the temperature setting until they reach the final image which represents ice, the frozen liquid. The ice is represented in a darker-blue than is the water with a flat texture and without the reflective qualities of the first image. In addition to the change in colour, the change from a liquid to a solid is represented by a change in shape. As the liquid freezes, the shape is shown as changing from the 'shape of the beaker' to a semi-circular shape representing the gradual freezing of a part of the liquid and then, as all the liquid has become frozen, filling the shape of the beaker. A change in shape, from what looks, front on, like a cube to the 'shape of the beaker' was used to realise the transformation from a solid to a liquid. The students read this change in shape as indicating a return to 'its original state'.

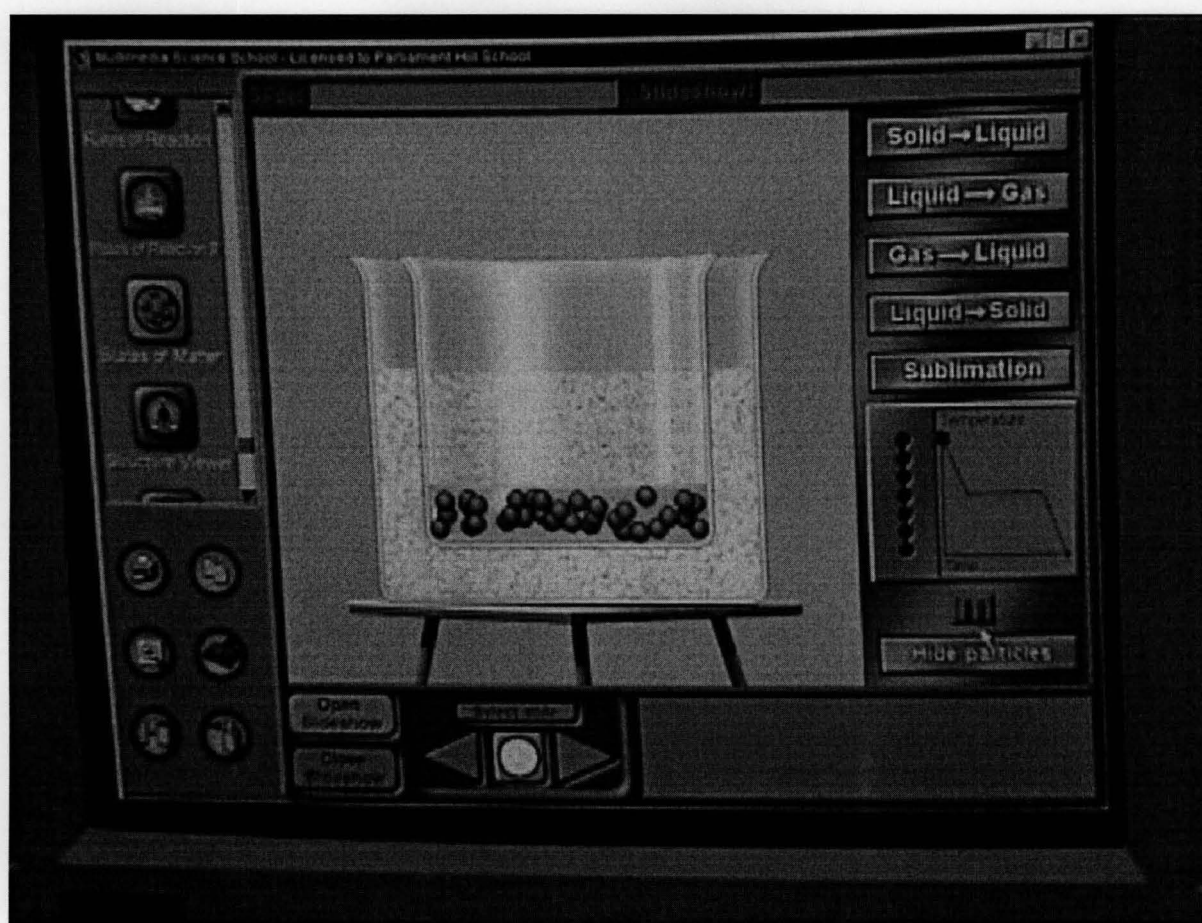


Figure 6.10 The opening screen of the transformation liquid to solid in the 'Hide particles' viewing option of the CD-ROM

The student, Kylie, who is working in the 'View Particles' option points at the representation of the 'particles' in a solid on the screen and says:

Kylie: Look. They're hardly moving

She then reads aloud the question on the work sheet (which she has read earlier)

'What liquid can you see in the picture and what could you predict might happen if you cool it down?'

Okay Lucy, what liquid is that?

Points at the representation of a solid on the screen

These two students opened the screen but they did not interpret what they saw as a liquid. They moved through the screens until they reached what they considered, due to colour, texture and shape, to be a visual representation of a liquid, but which is actually a representation of a solid. Kylie working with the 'View Particles' option comments on the limited movement of the 'particles' on the screen, a movement that she identified correctly as the movement of 'particles' in a solid in the earlier transformation from a 'solid to a liquid'. In short, the student's reading of the sign 'liquid' realised through image and colour 'overrides' their reading of the sign 'solid' realised in the mode of movement.

Lucy: It could be ice or it could be water.

Looks at screen at the representation of a solid in 'Hide Particles' option

Kylie: That, which looks like water yeah?

Points at screen again at the representation of a solid in 'View Particles' option

Lucy: 'Cos it looks like two beakers and one's ice and, if you just put a liquid in a kind of frozen beaker its obviously goin' to, um, get cold.

Points at the beakers on the screen

Kylie: So, that's water?

Points at the beakers on the screen

Lucy: So, if you cool it down. Yeah it probably is water.

I think it would, um, because if you go up to the top temperature its' frozen. So that's how it was when I turned it on to this. When you cool it down. So it melts.

Points at the screen [at what she thinks is a representation of solid but is actually a liquid]/ points at 'liquid to solid' key

The students take up the visual sign even though the writing clearly indicates that the direction of transformation is from 'a liquid to a solid' and therefore what is on the screen, for the students to look at, is a solid.

The move from the representation of a liquid as a light pale blue to a solid represented as a heavier, stronger blue indicates the designer's principle of the use of colour as a marker of 'density', 'compactness' or 'lack of movement'. Through the semiotic resources of the saturation of colour the solid is represented as a 'condensed' version of the liquid. However, the students read it as an everyday sign of cold and warm and in doing so they associate the pale colour of the liquid with the pale translucence of ice and more generally 'coldness'. Using the same principles the students read the darker blue used to represent the ice as being 'like water' and more generally as 'heat' or 'warmness', as being 'warmer'. The more intense saturation of the colour, where 'intense' seems to be the feature that the students have focused on, is interpreted as 'energy' and 'warmth'.

The difficulty that some of the students experience in interpreting the representation of the transformation from a liquid to a solid is rooted in their difficulty in reading all of the modes as meaningful. The students have to resolve a contradiction, and do so by use of their 'everyday' principles. In their reading of the multimodal signs of the screen the students rely on colour and the mode of image more than on the modes of writing and movement to making sense of what is displayed on the screen. This can

be understood as a result of the students' trust of the colour and image and their positioning of these two modes as empirical evidence within the CD-ROM. The students consider change in colour as a criterial aspect of the transformation. Year seven students are at an early stage of their induction into the realism of school science. Perhaps as a result, the students are faced with the challenge of 'reading' and untangling the tensions between the everyday and the scientific representations that the CD-ROM offers them. I want to suggest that some of the students were therefore more inclined to make sense of certain aspects of the representations that they were offered via image and colour from the perspective of their knowledge and experience of the everyday world. Even when the students were able to read the transformation multimodally, as intended by the designers of the CD-ROM, as a change from a liquid to a solid, they commented on the change in colour, writing for example 'I can see the colour change'.

The Resources of Movement on Screen

The modal resources of movement are central to how the curriculum entities 'states of matter', 'solid', 'liquid', 'gas' and 'particles' are constructed in the 'View Particles' option of the CD-ROM. Within the modal resource of movement, the features of speed, fixedness and freedom (of movement) and direction are used to represent these entities. Although the modal resources of movement are central to the design of the CD-ROM and the representation of the entities, these resources were not central to all of the students' engagement with the CD-ROM (their interpretation of it) or their construction of the entities. The main function of movement in the students' 'reading' of the CD-ROM is to signify change and to draw attention to the specific arrangements of 'particles' in the different states and the need to attend to the process of transformation from one state to another. In this way the resources of movement link one 'state' to another and in doing so this offers a new potential to generalise the entity 'particles' beyond a specific state of matter. In the move from the 'Hide Particles' viewing option to the 'View Particles' viewing option the modal resources of movement represent both the empirical phenomena, such as the movement of

water boiling in a beaker and the ‘motivating force’ that produces this movement, that is the movement of the ‘particles’.

The students interpreted the resources of movement in the ‘Hide Particles’ view as a sign of change and transformation. In the ‘View Particles’ option the students read the resources of movement more literally: they describe the movement of the ‘particles’ quite literally, without interpreting it as a sign – that is they describe the signifier without being able to link it with what it is that it signifies. In the case of the transformation of a gas to a liquid, for instance, several students describe the ‘particles’ as ‘moving up’ or ‘coming down’ and describe the change in speed and direction of the ‘particles’. However, they did not link these signifiers of movement to the transformation of a gas to a liquid. Their ability to ‘read’ the signs of movement is restricted by their understanding of the theoretical entities that the signs relate to. The students appear to read the resources of movement in relation to the specific ‘states of matter’ – that is to identify the movement of ‘particles’ in a solid, a liquid or a gas, rather than to read them as signs of a process.

Although the students comment on the movement of the ‘particles’ in the investigations that they observe on the CD-ROM the terminology that they use varies considerably. I want to suggest that their comments can be read as a sign of their ability to interpret the movement as scientifically meaningful. For instance, one of the students, Lucy, considered to be particularly good at science described the movement of the ‘particles’ in ‘scientific- technical’ terms such as ‘moving freely’, ‘restricted movement’, ‘move faster’ and ‘move slower’. Another student, Kylie, used terms such as ‘come out quick’, ‘move just a bit (not even an inch)’, ‘move much more than before’, ‘move a bit not much’, and ‘the particles hardly move a bit’. I want to suggest that the students’ ability to ‘strip away’ the everyday to reveal what is criterial to school science is at play in their potential to interpret the movement of the ‘particles’ as meaningful. Although both of these kinds of working might be thought of as being ‘theoretically the same’ the theoretical and epistemological force that

motivate the use of the signs ‘restricted’ and ‘free’ versus ‘move a bit not much’ are different. The former is motivated by the epistemology of science and the later by the epistemology of the everyday. In other words the student’s interpretation and description of the movement of the particles can be understood as a sign of their epistemological position to the phenomenon ‘states of matter’.

The Written Resources on the Screen

The students’ engagement with resources of the CD-ROM suggests that they do not interpret the events within the screen via the written labels on the ‘frame’. For instance, when working with the transformation from a liquid to a solid the writing on the ‘frame’ of the screen clearly indicates what it is that they are observing in the screen within the screen and yet their interpretation of this is not informed by the written label. They rely solely on the two visual modes of image and colour to ‘read’ the transformation. In short, the students do not ‘take up’ the information that the scientific ‘frame’ of the CD-ROM offers them. This is, I argue, an instance where the conceptual ‘gap’ between the different modal representations on the ‘frame’ and the ‘screen within the screen’. I argue that it is also an example of the dominance of the visual mode on the ‘screen within the screen’ and a de-centring of the role of written language on framing the screen. (Of course some students may not read these two elements in the way that they are designed to be read, that is together as a multimodal text.)

The Display of ‘Hide Particles’ or ‘View Particles’ in the ‘Screen within a Screen’

The potential to either hide or view the ‘particles’ in each of the multimodal representations of the states and the changes to states demands the students select and move between different epistemological views of the phenomena. For instance, selecting the ‘View Particles’ option means that the representation shifts from a specific common sense representation of a solid, that is, ice, to a theoretically informed multimodal representation of the state ‘solid’ – as ‘particles’ moving around

a fixed point and tightly packed together. The focus of what to attend to is changed with the potential to observe the usually unobservable behaviour of 'particles'. In the 'Hide Particles' view a change in state is reflected in a visual change of shape and texture, and movement. The question of what motivates the change of shape is answered at a general external level; that is the change is represented as being motivated by heating or cooling. (Although this too is represented as needing an 'external cause', hence the tripod.) In the 'View Particles' viewing option the representation of what motivates change is now seen as an 'internal' matter, a change of the particle arrangement and movement. The focus of what the students are required to attend to has changed. The 'View Particles' viewing option offers a theoretical explanation visually: a different view of the phenomena displayed.

Some of the students engaged with the entities 'states of matter' and 'particles' as instructed by the worksheets, first working in the 'Hide Particles' viewing option and then in 'View Particles' option. For example, one student Jemima observed the ice melt in the 'Hide Particles' viewing option and when viewing the liquid on the screen she switched to the 'View Particles' option, and, using the temperature settings, she observed the liquid change back to a solid in the form of an ice cube. By moving between these two epistemological views she moved from the specific to the general view of 'states of matter' – from the representation of 'common sense' to the representation of 'school science' theory of 'particles' and 'states of matter'.

The choice of viewing position was taken up differently by three students whom I observed working together in the lesson. One, Lucy, worked primarily in the 'Hide Particles' viewing option, and the other two, Kylie and Connie, worked primarily in the 'View Particles' viewing option. Although these students were working on separate computers they observed the displays on screens across all three computers. The students' different choice of viewing positions (viewing positions that might in any case conform more with their own position epistemologically) informs their

exploration and construction of the entities 'liquid' and 'gas' and 'particles', as this example of their engagement with the transformation from a liquid to a gas shows.

Lucy: So, what do you think will happen when we heat up the water?

Watching the screen as water boils in the 'Hide Particles' option

Connie: *Shakes her head and shrugs her shoulders*

Kylie: *Looks at the screen with the 'View Particles' option – temperature setting on low*

Lucy: So it says 'what can you see in the picture'? Water.

Kylie: *Looks at the screen as the water boils with the 'View Particles' option*

Kylie: Look! Look!

Lucy: Oh my God! Yeah go liquid!

Kylie: Go liquid to gas!

Lucy: Argh!

Connie: *looking at her own screen, temp not as high as L's*

Why are they floating away?

Lucy: 'Cos they are gas so they've got to be in the air. We breath in particles of dust

Look its starting to boil

Watching the screen as water boils with the 'Hide Particles' option

Kylie: I need some help. I've got it yeah, but I don't know what I've done to make it that way.

Lucy: That looks like water don't it?

Kylie: Yeah

Lucy: So. What will you predict when it heats up?

What happens when you heat water up in a saucepan?

Kylie: It goes hot.

Lucy: What does it do?

Kylie: You mean it boils?

Lucy: Yeah. I predict it will boil.

Looks at her screen in 'Hide Particles' option the water has evaporated
Argh my water's gone!

Remaining in the 'Hide Particles' view she selects the starting temperature setting and begins to raise temperature until the water evaporates

Switches to 'View Particles' but does not raise the temperature setting

Write her answers on the worksheet

Kylie: You know number four, yeah. I've writ' 'they're still on each other but they move a bit, not too much'.

Watching the liquid in the 'View Particles' option

The students' choice of viewing option on the CD-ROM can be understood as a sign both of which aspects they are attending to in the phenomena 'states of matter', and how they position themselves in relation to the production of knowledge in the science classroom. Lucy stays primarily in the 'Hide Particles' viewing option and does not explore the transformation in the 'View Particles' option she is observing the everyday for evidence. She stays at the level of 'guess' or 'hypothesis' and answers the questions posed by the teacher without engaging fully with the scientific representation. Yet she occupies an expert/teacher role (she both takes this role and is 'presented' with it by the other students). In contrast, the two other students, Kylie and Connie only view the transformation from a liquid to a gas in the 'View Particles' viewing option. Their 'predictions' are a matter of interpreting what they can see, and matching this with the teacher's questions on the worksheet. 'Prediction' for them, is a matter of record. Another student, Jemima who moves from the 'Hide Particles' view to the 'View Particles' option is involved in a different process, she is involved in prediction, observation and explanation.

The students' choice of 'point of view' serves to position them differently to the entities and more generally to the learning of science. The student, Lucy, who works with the 'Hide Particles' option focused her observations on the empirical representation of the surface appearance of the phenomena and the task of predicting what will happen. This choice positions her as being able to imagine the 'particles' – having a given knowledge of the scientific theory that underpins the explanation of

what she observes. The students who work with the 'View Particles' option are engaged with the scientific explanation of the phenomena. Their task is to relate the visualised particle theory to her everyday experience and knowledge – her work is a matter of interpretation of the explanation that she is presented with rather than one of prediction. The different viewing positions offered by the CD-ROM bring forth different discourses of what is being represented: the former is in terms of, for example, 'water boiling', while the latter is in terms of the arrangement and behaviour of 'particles'.

The Interaction of Modes on Screen

In reading the different modal resources and in specific ensembles as they appear on the screen the students can privilege one mode over another, more specifically they privilege image and colour over writing and movement.

In the case of the transformation from a liquid to a solid, the students that I observed 'read' the visual representation of a liquid to be a solid even though the writing and the movement of the 'particles' indicated it was a Liquid. This incident is interesting as it shows how the students engage with the modal representations on the screen differently to make sense of the representation. In particular it shows the modes that the students privilege or foreground for them as being the most 'reliable' modes in their reading of the screen at this moment. The multimodal sequence that the students are watching on the 'screen within the screen' is clearly labelled in writing in the 'frame', however, and through the use of the yellow highlighted key as being 'liquid to solid'. The movement of the 'particles' indicates that in the opening screen the 'particles' are moving more freely and faster than they are in the final screen in which the 'particles' move slower 'hardly at all' and are compactly arranged. The direction of the line plotted on the graph shows the temperature at the top of the graph as being 'higher' than the temperature at the bottom of the graph – that is the directionality of the graph represents a decrease in temperature. The students' talk demonstrates that they understand the temperature is being decreased – that the substance is being

cooled. Despite the construction of the state of matter via the resources of writing, directionality, and movement on the screen the students cannot read this as a solid and I want to argue that this is due to the resources of image, colour and texture.

The Positioning and Agency of Students

In the previous sections of this chapter I have discussed how the multimodal resources of the CD-ROM as they are displayed on the screen shape the curriculum entities within the lesson, that is the realisation of the 'ideational' 'meta-function' (outlined in chapters Two and Three). In this section of the chapter I explore how the resources that are displayed on the computer screen serve to create particular relations between the students and the world of science presented and framed by the CD-ROM, in other words the 'interpersonal' 'meta-function' (outlined in chapters Two and Three).

The semiotic resources of distance, contact and attitude are used to realise complex and subtle relations between the elements represented on screen and the students. Through the semiotic resource of distance (e.g. 'close' versus 'distant') the display on the screen is made to seem close to the students. The students are visually positioned near to the equipment (about one or two feet away) similar to the distance that they would be if they were conducting an investigation in the classroom. Attitude, the horizontal or vertical visual angle used to represent an element in an image, is a visual semiotic resource that encodes the position of the viewer. In the case of the images on the CD-ROM a frontal horizontal angle is used and visually this creates a maximum involvement - the student is directly confronted with what is in the picture. Through the use of vertical angle the CD-ROM positions the students as looking very slightly down on the elements in the picture, indicating the potential power of the students in relation to the investigation.

The visual representations of 'states of matter' on the screen visually position the student as the observer and actor in the investigation. However, in real terms the

student is an observer of the investigation displayed on screen, and acts on the CD-ROM, and not on the elements on screen. By selecting the temperature setting, the student activates the series of sequences in the multimodal representations displayed on the screen. There is an interesting confusion of the agency of the students within the CD-ROM in that the graph both visually positions the students as observers and as the agents of change. It would have been possible to design the interface to make it explicit that the role of the student is to move on the multimodal display; that this is not the case suggests that another interest overrides this logic of agency. I want to suggest that it is the demands of the curriculum, the need to foreground that the changes in state being displayed come about through heating and cooling; and this demand has shaped the designed agency of the students. The use of the temperature setting draws attention to the 'active agent within the system' – increase and decrease in temperature.

When working with the CD-ROM the students construct their agency in different ways. The students' responses to the worksheet questions show that some of the students construct themselves as active agents in the investigation by linking their actions with the display of the transformations from one state to another while other students construct themselves as observers of the investigation. This different positioning of agency can be seen in the students' response, for example to the following question on the worksheet concerning the change from a liquid to a solid:

Increase the temperature in the same way you did before. What can you see happen to the particles? How do you think this has happened? Have you done anything to make this happen?

One student, Lucy, responded 'Because I have raised the temperature the particles form into a liquid and move freely'. Another student, Jemima, commented, 'The particles are moving about a lot. Because the ice has melted it isn't a solid so it isn't packed tightly the particles. I didn't do anything.' While another student, Kylie, wrote, 'I've increased the tempature so they move more. I think this has happened

because of the heat. Yes I've done something I had raised the tempture.'. These comments can be read as 'signs' of the student's writing themselves 'into' or 'out of' the investigation and the extent to which they see what happens on the screen as a result of their action or the action of the system.

Student Roles

Through their use of the CD-ROM the students take on different roles in relation to the production of knowledge. The three students who work 'together' take on different roles one, Lucy, takes the role of the 'expert' and the others takes on the role of an observer and questioner. For instance in the role of the 'expert' Lucy reads aloud and rephrases the questions of the teacher, and the comments of the other students – for example, when the student comments that the water will 'get hot' she corrects this to 'it boils'. She also checks the other students have understood what she has said. The other student consistently calls on this student for explanation and guidance, for instance, she says 'I mean I've done...but I don't understand how I got there', and tells her what she is writing on the worksheet.

The CD-ROM on the Interactive Whiteboard

In the second part of the lesson the teacher brings the students together as a class to discuss 'what they have found out' using the CD-ROM on an interactive white board. This part of the lesson involves the students volunteering to present the transformations of state of matter displayed on the CD-ROM to the class. The first four students whom the teacher selects present the 'states of matter' in the 'Hide Particles' viewing option and the second four students present the 'states of matter' in the 'View Particles' option. The teacher's separation of the 'Hide Particles' and the 'View Particles' options in this way first enables a 'problem space' to be defined and then a theoretical answer to this problem to be established.

In this section I describe the two presentations of the transformation from a gas to a liquid. I have selected this particular instance as it is typical of the multimodal

realisation of the other ‘states of matter’ on the CD-ROM and it is the most complex example as it involves a ‘double’ transformation – from a liquid to a gas and from a gas to a liquid. This complexity raises interesting issues for the multimodal shaping of knowledge in the applications of new technology. By attending to the teacher-student interaction with the ‘Hide Particles’ and the ‘View Particles’ options I draw attention to the different functions of the two epistemological views of the phenomena.

Creating the Need for an Explanation: Displaying the Empirical

The Student who presents the transformation of a gas to a liquid in the ‘Hide Particles’ viewing option stands at the front of the classroom by the interactive whiteboard next to the teacher who sits on a desk. The ‘gas to liquid’ key is selected and the screen shows a saucepan containing boiling water placed on top of a tripod with a Bunsen burner underneath it (shown in figure 6. 11).

In the episode described below the teacher and students work with the resources of the screen to establish the ‘empirical reality’ of the screen, to identify the phenomena to be explained – the ‘problem space’ and to create the need for an explanation.

Setting up the Investigation as ‘Empirically Real’

The teacher starts by asking the student, Kate, to describe the elements on the ‘Gas to Liquid’ screen with the ‘Hide Particles’ viewing option.

Display on Screen: Gas to Liquid Screen with the ‘Hide Particles’ viewing option (as in figure 6.11)

Teacher: What am I doing here?

Points at the boiling water on the screen

Kate: Boiling water.

Teacher: Boiling water. Okay how am I doing that?

Kate: You put it in a

Teacher: What do you do at home?

Kate: Put it in a pot

Teacher: So I put it in a pot, and what am I doing down the bottom there?
Points at the saucepan/ points at Bunsen burner

Kate: And then you lit a Bunsen burner under it.

Teacher: Great. You put a Bunsen burner under it.

The sequence of the teacher's questions and his gestures with the screen serve to foreground the action of heating the water and to provide a realism of the events displayed.

Through their talk, gaze and gesture with the screen the student and teacher present the visual elements on the screen as a product of the teacher's action (or, I would argue more generally, the product of the 'users' action). For instance, the teacher's questions 'what am I doing now', and 'how am I doing that?' position him as an active agent in the investigation and the screen as a window onto his actions. In response the student offers a description of the teacher's imagined action in setting up the investigation that produces a procedural inventory of his actions. The description of the imagined process of the teacher setting up the investigation presents the display on the screen as an empirical reality akin to the science classroom laboratory. It introduces echoes of the traditions of the science classroom where students might set up and conduct such an investigation. The interaction of teacher and student with the screen serves to connect the screen with the classroom of the past. The connection that the teacher and student talk into existence between the screen and the classroom (present and past) is also established visually by the elements and realism of the screen. This connection glosses over - or put more strongly 'denies' - the reshaping of the student's agency that takes place in the move from page to screen.



Figure 6.11 The transformation of a gas to a liquid in the 'Hide Particles' viewing option



Figure 6.12 The transformation of a gas to a liquid in the 'View Particles' viewing option

Identifying the Phenomena and the Need for an Explanation

Having established the empirical ‘reality’ of the investigation, the teacher works with the students to construct the ‘problem space’ or phenomena to be explained - the transformation from a gas to a liquid. In short the teacher works to establish the need for an explanation.

Display on Screen: Gas to Liquid Screen with the ‘Hide Particles’ viewing option (as in figure 6.11)

Teacher: Yep and what’s happening to my water now at the moment?

Points at water

Kate: Its boiling

[Looking at the screen]

Teacher: its boiling excellent. What am I seeing happen at the top? Where my lid is?

Teacher points at the saucepan lid

Kate: Water’s dropping

Looking at the screen

Teacher: Water’s dropping down.

Okay. Any ideas why that’s happening?

Kate: *Looks at teacher, looks at the screen and shrugs her shoulders*

Teacher: What do you think’s happening there? Why is my water turning into a liquid there?

Points at the water in the pan/ points at water on the saucepan lid

Go on, what’s that word you used just now?

Kate: Condensation

Teacher: Condensation. Why do you reckon we’re getting condensation? Any ideas? There’s a question for Miss Power [the student].

S2: Because the steam from the Bunsen burner. From the boiling is, making, is coming through the water, and so the steam from

underneath it is condensation from going through the water, and its making it bubble and coming out the top.

Teacher: Okay. Right good you've described for me certainly what I've got here. I've got my water boiling here, my steam's coming up and hitting my lid at the top

Points water in pan/ raises finger from water to lid / holds finger under lid

S3: Is it also condensation as when something outside is cold and something inside is hot and the coldness and the hotness make.

Teacher: Okay. If we look at my diagram where's the hottest part of my diagram?

Kate: *Points at Bunsen burner*

Students: The bottom

Teacher: Well done. Look at where my liquid is dropping down from up on the lid, is that going to be cooler, the same temperature or hotter than my Bunsen burner?

Points to area of the screen with liquid/ points at the Bunsen burner

Students: Cooler

Teacher: Cooler. Why is it cooler?

Students: 'Cos its further away from the heat

Teacher: Yeah. Well done.

The teacher continues to construct the experiment as something that he has set up through his choice of language ("my water", "my lid", and so on). The construction of the problem space, the question of how and why the water gets from the saucepan to the lid is depicted visually on the screen. Working with the screen the teacher and student draw attention to the water 'dropping down'. The teacher clarifies the phenomenon to be explained, against the backdrop of the continuous display of the water dripping from the saucepan lid on the screen. The teacher creates the need for an explanation: the question shifts from 'what is happening?' and to the question

‘why is it happening?’). At this point the task of the students shifts from ‘observation’ of the screen to predicting and theorising what is happening.

In asking the students to explain what is happening on the screen the teacher’s use of language distinguishes between the ‘water’ in the pan and the liquid on the lid of the pan. The teacher’s use of everyday and scientific terms to describe a liquid serves to mark what it is that the students are being asked to explain and attend to in this instance – that is, the liquid on the lid of the pan. The scientific word ‘liquid’ is connected semantically with the word ‘particles’ in a way that the everyday term ‘water’ is not. The semantic distinction between ‘water’ and ‘liquid’ indicates the specific but everyday character of the water in the saucepan in contrast to the generalised character and ‘scientific potential’ of the ‘liquid’ on the lid of the pan.

The multimodal sequence displayed on the screen, together with the talk of the teacher, enables the students to theorise that something is happening that cannot be seen. At this stage the students draw on their everyday knowledge of boiling water in the home to understand that the unseen entity is steam and that the process that they are observing is condensation. In the ‘Hide Particles’ viewing option the gas ‘particles’ are not visible and they therefore need to be talked into existence – a narrative overlay is needed to explain the representation of the empirical phenomena that is displayed on the screen.

A student offers such a narrative in her explanation of condensation. In explaining condensation the student speaks of the water and the steam as unconnected entities, she does not link one to the other as in a process of transformation. She suggests that the steam ‘comes up’ through the water - that the steam exists separately in the water, that it is what makes the water ‘bubble’ and that the steam comes out of the top of the water. The student’s spoken representation of the relationship between the gas ‘particles’ and the water is an accurate re-presentation of the visual representation of the transformation from gas to liquid that is shown in the ‘View Particles’ viewing

option. (She would have seen the ‘View Particles’ version of the transformation of a gas to a liquid in the first part of the lesson - the representation shows the water bubbling and the ‘particles’ leaving the ‘top’ of the water to collect on the saucepan lid (see figure 6.12).) The teacher rephrases the student’s explanation and in doing so he ‘strips away’ her confusion and ambiguity and he brings into existence the unseen gas ‘particles’ through his gesture (he raises his finger as a particle from water to the saucepan lid). Alongside his gesture and talk the teacher uses the image displayed on the screen to introduce the concept of heating and cooling to explain the transformation that is shown. Through his use of gesture with the screen, through talk and image he establishes an empirical frame into which particle theory can be introduced in the next part of the discussion.

Through the ‘Hide Particles’ viewing option the teacher establishes the connection of (school) science with the ‘everyday’ empirical world, and the potential of science to address the questions and problems that people identify through their engagement with the everyday world. The limited explanatory power of observing the everyday world is made clear and the need to think beyond what can be seen is established. In his push to move the students beyond their observations of the everyday the teacher ‘ignores’, he does not pick up on, one student’s example of the everyday (“It is also condensation as when something outside is cold and something inside is hot and the coldness and the hotness make.”). The need for explanations to ‘look deeper’ is realised in the move to the ‘View Particles’ viewing option.

Scientific Explanation of Phenomena

In the next stage of the discussion the teacher switches the viewing option to ‘View Particles’ and asks the students to describe and explain the transformation from a gas to a liquid.

The teacher’s spoken distinction between ‘water’ in the pan and ‘liquid’ on the lid of the pan when working in the ‘Hide Particles’ option is visually realised in the ‘View

Particles' representation of the transformation of gas to liquid. The water in the pan is realised as an 'everyday' representation of water bubbling in a pan. In contrast the water that has condensed on the lid of the pan is represented as 'particles' moving against a pale-blue background - that is, only the water labelled 'liquid' is realised visually as 'particles'. In this way the visual display on the screen draws attention to (visually foregrounds) the specific transformation that is to be attended to, that is the change from a gas to a liquid rather than the change from a liquid to a gas.

The focus in this sequence of the CD-ROM on only one of the two transformations actually being shown demands that the students imagine the movement and the arrangement of the 'particles' in the water and the transformation from a liquid to a gas.

Making Visual Links and Patterns

The teacher starts the episode by drawing attention to what is not visually present on the screen – the 'particles' in the boiling water. Using the resources of the CD-ROM he works to 'compensate for' the limitations of the CD-ROM in showing the process of transformation from a liquid to a gas and from a gas to a liquid. He does this by moving between the representation of 'a liquid to a gas' and 'a gas to a liquid' and in doing so he visually links (making a visual comparison) between the two screens.

Teacher selects the Gas to Liquid screen with the 'View Particles' viewing option

Teacher: Now Margaret's got a tough job here because I can't really see my 'particles' down here

Points at the water in the saucepan

But if I know that I've got a liquid boiling.

Teacher selects the Liquid to Gas screen with the 'View Particles' viewing option

I know if I go back to my original one.

The Teacher increases the temperature by clicking on the temperature setting [the representation shows the water begin to boil and the 'particles' begin to leave the liquid]

My particles are quite busy; they're moving quite a lot and they've got quite a bit of space.

Teacher selects the Gas to Liquid screen with the 'View Particles' viewing option

So, we've got to presume that's happening there.

Points at the boiling water in the sauce pan

By moving between these two sequences within the CD-ROM the teacher offers the students a multimodally realised theoretical filter with which to view the boiling water shown in the transformation of a gas to a liquid. He offers the students a tool to imagine with. He also generalises the 'particles' beyond a specific transformation – that is by moving from one sequence to another he visually makes the point that the 'particles' are 'the same' regardless of the state of matter, rather it is their arrangement and movement that changes. He introduces the potential to move between the screens as a resource for thinking, and to generate and check explanations. The facilities of the CD-ROM enable the teacher to highlight the role of observation to create and to reveal patterns of behaviour within (school) science. Finally, by making the 'particles' in the boiling water 'temporarily' present in this way the teacher is able to 'correct' the disconnection between the water and the steam expressed by the student in her earlier explanation of condensation.

Explanation of Phenomena

The teacher, having established a fuller view of both of the transformations of 'states of matter' that are represented on the screen, asks the students to describe and to explain what she can see.

Display on screen is the Gas to Liquid screen with the 'View Particles' viewing option

T: Talk to us Margaret. What's happening here? What can you notice?

Points at the water in pan and moves finger up towards the lid

Margaret: Um. The water's bubbling

Teacher: Okay. The water's bubbling. What can you see coming out of the, out of the um, saucepan here?

Points at space above the water/ makes hand flat and moves it across the surface of the water and then up wards

Margaret: Um, particles are coming up and falling back in.

Teacher: Okay. Particles are coming up and falling back in.

Points upwards/points downwards

But what we said before was, that the reason why they were falling back in was because it was colder up here.

Points pan lid and then downwards/Points at pan lid

Okay. So if we look at the particles up here what, um. If we look at the arrangement of the particles could we predict this to be a solid, a liquid or a gas?

If you look at how the particles are arranged up here?

Points at the particles on the lid and repeatedly runs his finger across them and back again

Students: A gas

Teacher: Now, how are gas particles arranged? Are they really spread out, or are they kinda close together, or really close together?

Students: Really spread out

Teacher: So are they really spread out here?

Points at the particles on pan lid and circles them

S2: I think it's a liquid

Teacher: Why ? Look at the particles

Points at the particles on the pan lid

S3: Yeah, I do .Condensation.

Teacher: Go on

S3: Condensation is a liquid, 'cos then there's water.

- Teacher: How do you know that by the particles?
Points at the particles on the pan lid
- S4: When you lift up the lid there's always water there
- Teacher: Good yes.
- S5: Or when you have a shower and you get out and you feel the mirror
- Teacher: Good yes. But how do I know from these particles that I've got a liquid?
Points at the particles on the pan lid

In the 'Hide Particles' viewing option the teacher focuses the students on observing the screen to identify the problem space and to make hypotheses based on their everyday knowledge and experience of the world. In the 'View Particles' option the teacher shifts the purpose of observation to a matter of a visual explanation of the problem space. The teacher positions the visual display on the screen as a matter of evidence. The student is faced with the question of what it is that she should attend to – what is to be 'noticed'. The student comments on the directionality of the 'particles' - they go up and 'fall back' down (as they collect and return to a liquid). The teacher, however, wants the students to focus on the arrangement of the 'particles'. His 'hesitancy' and 're-formulation' in describing what can be seen (e.g. "Okay. The water's bubbling. What can you see coming out of the/ out of the um/ saucepan here?") 'overrides' the confusion expressed earlier by the students which served to separate the gas particles from the liquid. By referring to the gas particles coming out of the saucepan, rather than the water he bypasses the transformation of liquid to gas.

Through his repeated gestures with the screen the teacher indicates that the students should attend to the arrangement of the 'particles' on the saucepan lid. The teacher's repeated verbal and gestured demand that the students 'look at the particles' makes clear that abstract theorising is no longer adequate: he wants the evidence. The screen provides a multimodal realisation of particle theory. The change from the

‘Hide Particles’ viewing option to the ‘View Particles’ viewing option marks a shift in the students’ task from one of prediction to evidence, from theory to empirical fact.

Observation: Patterns and Comparison

Finally a student, Hilary, offers the teacher the evidence that he wants.

Hilary: If we go back to the liquid

Teacher selects the Liquid to Gas screen with the ‘View Particles’ viewing option (shown in figure 6.13)

We can see that they are moving around in the same kinda way.

Teacher: Good. They’re moving around kinda the same way and they’ve got kinda the same arrangement.

*Teacher selects the Gas to Liquid screen with the ‘View Particles’ viewing option
Points at the particles on pan lid and circles them*

If we look they’re kinda the same kinda arrangement. Excellent. Well done.

Circles the particles on the saucepan lid

The student, Hilary, adopts the style and the discourse of the teacher. The teacher facilitates the student positioning herself in this way by following her implicit instruction to change the screen image from ‘gas to liquid’ to ‘liquid to gas’. In doing so the teacher enables the student to take up the resource of visual comparison and movement between the screens in the CD-ROM. The observation is focused here on the drawing out of visual interpretations and patterns within the CD-ROM. This is a crucial point in the lesson as the comparison between screens enables the student to generalise the entity particle from a specific state of matter. The particle is no longer ‘a gas particle’ or ‘a liquid particle’ it is a particle that can be arranged to realise different ‘states of matter’. The student’s comments connect with the visual icon for the button ‘states of matter’ that started the lesson in which the image of ‘particles’ indicates the criterial aspect of ‘states of matter’.



Figure 6.13 The Liquid to Gas screen with the 'View Particles' viewing option

Conclusion

The resources of the screen and the students' engagement with these in the lesson result in a reshaping of the curriculum entity 'states of matter' and a change in the cognitive work required of the students.

Shift in Focus from 'State' to the 'Process of Transformation'

A central question in this chapter is 'what happens when we shift the focus to the process of transformation between states rather than the description of specific states?'. The transformation between the 'states of matter' is not, as I mentioned earlier, traditionally represented visually in the science classroom. Traditionally this aspect of the theory of 'states of matter' has been handled through speech, gesture, and so on; here, with the facilities of new technology the theory with a different focus is realised through movement.

The curriculum contents as realised in the traditional classroom are shaped as discrete entities / and 'states of matter'. In the move to screen and its potential for movement this is reshaped to focus on entity as 'process', so that the focus is on the transformation from solid to liquid or from liquid to gas. Nonetheless the ways in which these processes of transformation are realised on the screen continues to be shaped by the demands of the curriculum as traditionally shaped via the representational means then available. In order to adhere to the existing curriculum the potentials of new technology made available via the CD-ROM are not fully taken up. The visual representation of transformation between 'states of matter' on the static page is problematic, in the move to screen these problematic aspects remain. In short, the demands of the curriculum remain shaped by the resources of static representation even with the availability of the mode of movement. The CD-ROM shows the tension between the potentials of the old and the new in the reshaping of knowledge.

Change in Cognitive Work

The cognitive work of the students is to observe the empirical phenomenon and the scientific representation of them in order to identify patterns and generalisations in relation to the issue of 'states of matter'. In the classroom or in relation to the pages in the textbooks this work of identifying patterns is usually carried in the talk of the teacher and her/his gestures. The still images are presented as canonical representations and the written part of the text or the teacher's speech foregrounds, 'pulls out', the criteria to be attended to, that is, say the spatial arrangements and or the movement of the 'particles'. In the science classroom still images are usually used, and the focus is on the canonical representation of 'states of matter' (solid, liquid and gas). The teacher uses talk, gesture, imaginary demonstration and models to provide a narrative of the transformation from one state to another. Through gesture and models the teacher brings the 'particles' into existence and communicates some of their qualities through these modes. In the case of the CD-ROM image and movement are designed to 'fill in' the linguistic terms – the arrangement and movement of the 'particles' is shown – it is displayed but it is not explained linguistically, and to show the transformation from one state to another.

The work of the student and teacher is no longer focused on the work of bringing the 'particles' into existence, but rather the identification of patterns through comparison. In the process the students are repositioned in relation to knowledge as the producer of the knowledge the criteria for defining 'states of matter', whereas in the traditional science classroom the student positioned as a reproducer of knowledge, the learner in terms of acquisition of knowledge.

¹ The data on traditional science classroom is drawn from the ESRC funded research project 'The rhetorics of the science classroom: a multimodal approach' (1997-1999) on which I was the senior researcher, directed by Gunther Kress and Jon Ogborn.

Part III:

New Technology, Multimodal Learning, Literacy and Design across the Curriculum

7. New Technology and Learning

Introduction

Throughout this thesis I have set out to demonstrate that mode and learning are fundamentally connected. The analytical focus of the previous chapters is on the semiotic resources and affordances of modes. In this chapter however the focus is adjusted to foreground learning. I begin by considering how the thesis contributes to a better understanding of the relationship between the multimodal resources of new technologies and curriculum knowledge and learning. I open up this discussion more generally by returning to the six analytical themes of the thesis, outlined in Chapter One and woven throughout its chapters. My intention is not to say something final, to ‘tie up’ these thematic threads, rather it is to develop these themes as conceptual tools that may be useful for understanding technology-mediated learning.

The Multimodal Reshaping of Curriculum Knowledge and Practices

The multimodal analysis of the three instances of technology-mediated learning presented in this thesis demonstrates how the representation of curricular knowledge is capable of being modally reshaped by new technologies. I have shown that the multimodal character of new technologies can offer new potentials for students’ engagement with the curriculum, potentials that reshape the process of learning, what it involves and what it demands of students. Through focusing on the semiotic modes offered by new technologies I have shown that curriculum knowledge and learning is always shaped by mode and technology in rhetorical ways. I have demonstrated that knowledge and learning are a complex outcome of the relationship between the sign maker, the social context the sign is made in, and the sign maker’s perception of the audience. In other words, I have shown that knowledge is shaped by the interests and purposes of the designer of an application, the social organisation of the application’s context of use, such as its curriculum purpose, together with the rules and roles that surround and impact on its use, and the interests and purposes that students bring to

their engagement with an application. In the following sections I discuss the aim of the thesis in relation to my analyses of how the modal affordances of new technologies re-mediate the learning of school English, Mathematics, and Science.

The Reshaping of Curriculum Entities in School English

In the move from page to screen the CD-ROM of the novel *Of Mice and Men* reshaped the entities 'character' and 'novel'. In the move from page to screen the mode of image dominates the representation of the novel as an entity. The visual character of writing was foregrounded and used as a resource for indicating the relationships between the characters. This serves to equalise all of the characters and to connect the characters George and Curly's Wife romantically. This multimodal reshaping of character provided a multimodal filter through which the novel can be re-read by the students and re-orientates the narrative, 'overlaying' the racism and sexism of the novel and transforming the motivating force of the novel. This multimodal reshaping of character highlights the novel's theme of loneliness, and offers the students other analytical devices (such as metaphor) for its analysis, as well as providing them with different modal entry points into the novel as a text.

The original entity of 'novel' is repositioned in the 'Novel as CD-ROM' from a fictional entity to one that exists in the tension between fact and fiction. The hyperlinks between the places mentioned in the novel and a map and historical facts, together with the guide's comments on the socio-historical context of the novel and Stienbeck's intentions offer the 'reader' of the 'Novel as CD-ROM' alternative perspectives and resources for engaging with the narrative. In this way the practices of reading a novel for literary study and examination are embedded in and transformed through the multimodal resources and structure of the CD-ROM. The narrative of the 'Novel as CD-ROM' is re-presented, restructured, repositioned and transformed to account for the perceived concerns of a contemporary audience. Through the multimodal reshaping of the novel the CD-ROM highlighted characters newly and emphasises specific moments above others foregrounded in the original

novel. One outcome of this is to introduce a ray of hope in the potential of love between the characters George and Curly's Wife that subtly disperses the relentless misery and prejudice of the original novel.

The transformation of the entity 'character' and 'novel' is reflected in the function of the CD-ROM in the classroom. The focus of the 'Novel as CD-ROM' and the task of the students are no longer to come to know themselves through literature or to engage with questions of morality or identity. The analysis shows the reshaping of the entity 'novel' by a shift towards 'reality'.

The move from page to screen also reshapes the actual characters of the novel. The modes of gaze, movement, gesture, body posture and voice quality each contribute in specific ways to the re-shaping of the characters of the novel, in particular the characters George, Lennie, Crooks and Curly's Wife. For instance, the character George is re-presented as rational, stable, in control and adult through the representation of his steady gaze, his still body-posture, his lack of movement, his slow and soft gesture, and his regular voice tone, pitch and rhythm. In contrast the character Lennie is re-presented as emotional, unstable, out of control, dangerous and child-like through his fast and forceful gesture, his constantly shifting body-posture, unfocused gaze and faltering stutters. At some points the multimodal resources of the CD-ROM serve to polarise the two characters, and in other instances they serve to connect them. The visual positioning of the viewer through the distance and angle of the representation, the editing and composition of the video clips and the images on the CD-ROM foreground the designer's empathy for the character George and combine to objectify the character Lennie. In this process the character George is realised as active and the character Lennie is realised as passive and yet potentially dangerous. The multimodal ensemble of the CD-ROM indicates a 'designed support' for the actions of George and reveals the stark tensions between the two characters.

Alongside this the multimodal representation of the characters Crooks and Curly's Wife brings them into the foreground of the novel and increases their 'potential to mean'.

Reshaping the Practices of Students in School English

The multimodal resources of the CD-ROM provide the students with new resources for the engagement and construction of the entities 'character' and 'novel' in the English classroom. The multimodal construction of the entity character is dis-embedded from the narrative of the novel and this enables the students to engage with marginal characters in new and profound ways. It offered several young women a new potential to engage with the only female character in the book, Curly's Wife, through her emotional singing about her life, enabling them to empathise with the possible motivation for the character's behaviour. The multimodal 'humanising' of the only Black character in the book, Crooks, as an intelligent and oppressed man both re-positions him in the narrative and accounts for his marginal status and derogatory naming in the original narrative firmly within the context of racism. The multimodal construction of these marginal characters provides a multimodal filter for the students' re-reading and engagement with the novel.

The multimodal representation of character in the 'Novel as CD-ROM' enables the students to 'enter' the text in a number of ways, through the visual display and summaries of events, the multimodal video clips of key moments in the narrative, and the musical narrative created via the audio clips. The students could literally 'bypass' the novel as a written entity to engage with the novel multimodally as 'film', 'animation' or 'musical'. This offers the reader the potential for multiple reading paths and readings of the entities novel and character. Each of the different texts created by the movement of the students through the CD-ROM made different aspects of character and novel as well as the different experiences of the novel available to the reader. Further the multimodal representation of these entities in the 'Novel as CD-ROM' enabled the potential for the 'high' literary aesthetic of the

novel to be transformed by the students form of 'readings' to 'popular' forms, such as film and cartoon. This enabled the students to bring forms of engagement to the English classroom that they might be familiar with in their everyday literacy practices and as such expanded the notion of school literacy at that moment, even if temporarily.

The multimodal emphasis on the themes of the novel in the CD-ROM, together with the devices of authorial intent and social-historical context revealed in the structure of the CD-ROM, offer the students a meta-level entry into the novel and provides them with new tools for navigating the text. The structure of the CD-ROM offers new potentials for the comparison of characters and the need to think about the entity 'character' beyond the text, as a complex entity realised through the dynamic social interaction of many voices over time. This repositioning of the entity of 'character' served as a reflexive tool for its study.

Crucially, the resources of the CD-ROM offer students the potential to engage with the text both as 'imaginative non-fiction' and 'historical fact'. The entity 'character' is represented in the CD-ROM in a number of ways including 'character' as realised in the novel, stage and film productions of the novel, the realisation of Steinbeck's imagination (and life), and the fictional diary account of the harsh reality of the lives of 'real' people. This potential to engage with the novel both as fact and as fiction is important in light of current debates on gender and literacy which suggests that many boys find non-fiction a more accessible route into literacy (Moss, 2001). The CD-ROM's demand that students shift between the domain of fact and fiction, and the merging of the boundaries between the two, demands different kinds of imaginative work of the 'reader' than do the traditional focus of the novel as fictional literature.

The Reshaping of Curriculum Entities in School Mathematics

In the move from page to screen in the use of Toontalk in school Mathematics the entities 'rule', and 'bounce' are transformed. I have shown that each of the modes

made available by Toontalk, still image, colour, movement, and sound-effect contributes to the construction of these entities in specific ways.

The entity 'rule' is transformed from a conglomerate of the students' everyday experience and knowledge to the criterial elements that are significant to the mathematical concepts embedded in Toontalk, that is action, condition, and agency. In the students' game design on paper the entity 'rule' is formulated as a written narrative sequence of events and a visual display of the outcome of the rules of the game. Here rule is a fixed entity and condition and action are 'bundled' together. The move to the multimodal resources of screen and Toontalk require the notion of rule to be re-specified as consisting of separate entities to be attached to particular elements in the game. On entering Toontalk the entity rule is embedded in the city level of the game and the notion of condition and action are implicit but not defined. As the user/player lands the helicopter and he or she nears the potential to construct rules they are increasingly positioned through the modes displayed on screen as being in control of the objects on screen. The configuration of these resources on screen mark the entity 'rule' as something that requires a particular location in order to 'work'. For instance, on landing the helicopter on the ground the player character jumps out of it, or on instructing the character to kneel the toolbox automatically opens. This link between the behaviour of the player, location and movement (action) on screen can be read as an emerging 'definition' of the entities 'condition' and 'action'. The game environment of the city is a meta-level multimodal representation of the entity 'rule' and it suggests that rule building is not a question of being 'right' or 'wrong', but something that can be built, deconstructed, rebuilt, played with and amended. Rule is reshaped from a relatively fixed entity, to an open, iterative process with multiple possibilities. As the user/player moves to the Toontalk behaviour level the entity 'rule' is represented as consisting of two parts, that is, action and condition. However, these elements are not labelled as such and one of the tasks of the user/player is to distinguish between these elements of 'rule'. Modes are central to this process as they are used to name and classify action and condition: the condition

is realised visually and in written mode, and action is realised through the mode of movement and/or sound-effect.

In the move from page to screen the entity 'bounce' is transformed from the representation of everyday experiences of the material qualities of an object to the behaviour of an object in interaction with other objects. Toontalk overlays the material 'reality' of children's everyday experience with other kinds of possibilities: bounce can be attributed to any object in Toontalk, a pig or a brick can be as bouncy as a super-ball. The modal affordances of animated movement and image require the students to move from thinking of bounce as a general kind of quality to a specific kind of movement. In doing so, the students are 'forced' to consider units of speed, angle and direction, and to consider what and how objects will interact to 'produce' the bounce.

The affordances of writing as a mode do not require the student to define or specify bounce or rule in their design on paper in the same way as Toontalk does. 'Bounce' is represented as the interaction of elements, realised in the transactional clauses of the written narrative and the sequencing of events as a linear narrative. The students named the elements of the game, the 'little figure' and the alien, but the affordances of writing enabled these elements to remain relatively open. When drawing a picture of the game, however, the affordances of still image as a mode demand that the students specify the size and shape and features of the game elements and the spatial relationships between them. The entity 'bounce' is represented visually in the students' drawing through the genre of 'time lapse imagery' but the affordances of image do not enable the direction, speed or cause of the movement to be represented.

The affordances of image and writing on the page constrained the representation of the final outcome of the game in which the 'little figure' explodes the 'sound' and 'effect' of which was represented visually as a wiggling wavy line engulfing the little figure. Through the spatial non-linear affordances of image the students represent the

game elements as happening simultaneously and in a sense the drawing became a display of the combined process and final outcome of the game. Through their use of visual and written representation the entity 'bounce' is represented as a general kind of movement or quality.

When the students designed and constructed their game on screen using the multimodal resources of Toontalk, in particular movement, a different kind of epistemological commitment was demanded of them. The move from page to screen and the potential for movement reconfigures the temporal dimension of the written game narrative and the spatial dimension of the visual depiction of the game. As a result the entity bounce is transformed through the representational resources of movement in space over time. The character and function of the game elements is realised through the use of movement. For example, the little figure attempts to flee, its movement constrained to moving right and left, as the alien stands still and attempts to shoot it. In short, the mode of movement is a sign of the power of the alien, and the weakness of the little figure. The point here is that movement demanded that the 'agents' of the events be clearly defined by the students and the entity 'bounce' is constructed as the conjunction of agency, movement, speed, and angle, which moves the concept of bounce beyond the inherent quality of an object.

At the level of Toontalk behaviours, 'bounce' is realised multimodally in written mode, image, and movement. Behaviours, as I described in Chapter Four, have two 'states' (sides), the 'action-state' and the 'edit-state'. In the action-state the mode of writing lexically names the behaviour, in this case 'bounce', the mode of image classifies the kind of movement through iconic signs (a spring) and movement is used to display the behaviour itself, the movement of bounce, its direction and speed. The edit-state consists of a written explanation of bounce in mathematical terms, the Toontalk code for bounce, and the iconic image of the spring. In this way, the bounce behaviour offers both an everyday representation of bounce in the 'action-state' and a scientific/mathematical representation of bounce in the edit-state. The shift in the

representation of bounce from the everyday to the scientific in Toontalk is realised in the difference between the coding-orientation of the two representations of bounce. This is realised through the shift from the bright primary colours and the 'lego-like' texture associated with play to the darker colours and flat decontextualised texture associated with technical imagery, together with the introduction of mathematical symbols and the backgrounding of movement as a mode. The mode of image, the image of the spring, mediates these two spaces (image plays a similar mediating role in the case in the Steinbeck CD-ROM). These multimodal representations of the entity bounce provide the students with the potential for multiple readings and simultaneously to hold both everyday and scientific accounts of a phenomenon.

Reshaping the Practices of Students in School Mathematics

In the process of designing and building their game the students engaged in a range of activity including the construction and deconstruction of rules, hypothesising and prediction, and explanation and problem solving. The multimodal resources of the Toontalk environment were central in how the students engaged in these practices.

In building their game the students created different spaces through their gesture and gaze with/at the screen itself and through their interaction and organisation of the elements displayed on the screen. These different spaces they created through this activity drew distinctions between different kinds of practices that the students were engaged with, that is game design, game playing, game construction, and the saving of games. In their creation and use of these spaces the students set up a creative rhythm between their different kinds of activities which served to create a distinction between game planning, design and construction, and game playing. The students gestured 'on' the screen to produce a plan of the game. Through their use of gesture and gaze in this way the students connected their imagined idealised game with the resources of Toontalk. The temporary and ephemeral affordance of gesture and gaze as modes enabled the plan of the game to remain fluid and ambiguous. The students then selected and constructed the game on screen. When working with the resources

of screen the students worked visually. Once an aspect of the game had been constructed the students played the game and the movement brought to life their programming, which often did not work to plan (as I showed in Chapter Four). During this play the students were engaged in identifying problems with the game. Game playing was invariably followed by a return to the work of re-planning through gesture and talk, for reflexive thinking, problem solving and re-planning. In this way the process of building rules and the game itself was an iterative one of testing and fixing, and drew on the affordances of image and movement.

The multimodal resources of Toontalk and the screen, in particular movement, demand that the students engage with different kinds of imaginative work than do the modes of writing and image on the page. The modes of writing and image in the paper design did not require the students to think about what produces bounce, bounce was seen as a reaction and the students' uncertainty remained unattended to in this modal representation of the game. The multimodal ensemble of Toontalk offered the students different potentials for action that shaped how they designed their game on screen. The students were involved in the selection and ordering of the game elements in time and space. Much of this work was visually organised. What was visible on the screen proved to be particularly important throughout each stage of the game and rule design. When deciding where to attach the bounce behaviour, for example, if an element was not visible it was not considered a potential candidate. The students appeared to associate visual presence with agency, 'if it couldn't be seen it couldn't be acting' seemed to stand behind the programming process.

Within the Toontalk environment there is no clear reading path or entry point to rule making, the user/player has to find her or his own way through the multi-directional paths. The multimodal affordances of movement, the movement of elements on the screen and the interaction of the user/player with the application and the visual 'demands' of the environment revealed the 'ways into' Toontalk. The task of the user/player is, to some extent, to engage with these elements and to find what is

expected and required. Movement is used to construct the entity rule and its potential for movement, and is a constant metaphor for the making of rules such as animated hammers, robots and other tools populate the screen.

The modal resources of colour, image, movement and sound effect available in Toontalk require the students to re-specify the elements of the game: to fill in the concept of the game narrative. The visual design of the game does not only fulfil a decorative function, but is a crucial aspect of the game design which brings forth particular discourses of game and rule which in turn shape the interaction of the students with the screen as a text. In the move from page to screen the students are involved in the transduction of knowledge between modes, the representation of movement as static image and the representation of sound as visual image.

The Reshaping of Curriculum Entities in School Science

Image and movement are central to the learning of school science in the classroom and the construction of curriculum entities, the introduction of new technologies and the move from the page to the screen, however, reconfigures these modes in ways that are significant for the construction of curriculum entities. In the case of the construction of the entities 'states of matter' and 'particles' the work of bringing the entities into existence in the classroom is transformed. The task of animating the arrangement and movement of the particles in each 'state' is traditionally realised by the gesture and drawings of the teacher. In the move from page to screen the potentials of movement made available by the CD-ROM *Multimedia Science School* realise this aspect of the entity particles, and in doing so the agency of the particles and their 'empirical reality' is established. Traditionally, as I have shown in Chapter Six, teachers focus on discrete 'states of matter' and the arrangement of 'particles' in these states, however, the modal resources of image and gestured 'demonstrations' of the movement of particles are limited in the realisation of the transformation from one 'state of matter' to another. On screen the semiotic resources of image and movement are foregrounded and offer the potential to display the changes that occur

when a 'state' is heated or cooled; the focus is on the process of transformation between one state of matter and another.

The compositional arrangement of the modes on screen realises the two areas of 'frame' and 'screen within a screen', each of which shapes the entities of states of matter and particles in specific ways. The frame functions to 'name' the transformations of states of matter (e.g. liquid to solid) linguistically and to visually establish the entity 'particles' as criterial to 'states of matter'. Further the modal realisation of the 'frame', the use of image, colour, writing, and visual composition serves to literally frame what is to be attended to within the domain of science. The modal realisation of the 'screen within a screen' attends to the 'empirical world', specific everyday instances of the entity 'states of matter'. At the same time the 'screen within a screen' is a space which makes available the scientific view of the world (when the 'view particles' viewing option is selected). The 'screen within a screen' serves to mediate and provide the 'evidence' that 'fills-up' the linguistic concepts of the frame. The visual presence of scientific equipment on the screen serves to both represent the investigation as 'real' through its association with the traditions of the science classroom and to position the students as having the potential to actively engage with the display. The availability of these two different 'accounts' of the phenomenon 'states of matter', the everyday and the scientific, provides a productive tension in which each account 'explains the other', this tension and explanation is realised visually and through the modal resources of movement.

In contrast to the foregrounding of image and movement on the screen, the modal resources of writing are backgrounded on the screen. Writing appears only in the 'frame' area of *Multimedia Science School* and not in the 'screen within a screen'. The role of writing is limited to the naming (labelling) of the entities 'states of matter' and the transformation between states (e.g. solid to liquid), that is, on screen

writing fulfills a classificatory function and is de-centred in comparison with its function on the page.

The realisation of the entity 'particles', visually and through movement, on screen offers the students using the CD-ROM a new set of resources for their construction of the entity and their engagement with it. The potential to 'hide' or 'view' the particles provides two different views of the phenomenon being investigated in ways that reshape the entities and positions the students in relation to the body of knowledge in important ways. The 'hide particles' viewing option locates the entity in the everyday world of 'what is', while the 'view particles' option relates to a scientific view 'beyond (or perhaps beneath) the everyday' and the forces that underpin what is seen in the everyday. The resources of image and movement realise a link between one state of matter and another, as in each state the particles are represented as looking the same and moving slower or faster, and moving in a more free or constrained manner. The representation of the entity 'particles' on screen offers the potential for students to link the particles between the three 'states of matter' and to generalise the entity particle beyond a specific state. That is, the multimodal representation of particles enables a move away from conceptualising particles as either 'gas particles' or 'liquid particles', a move that marks a curriculum shift from a focus on discrete states to transformation between states.

Reshaping the Practices of Students in School Science

When working with Multimedia Science School the students are engaged in the work of prediction, observation, interpretation, explanation and drawing scientific conclusions. The practices that underpin this work are central to the learning of school science regardless of the technology used however the practices and the roles of students are reshaped and transformed by the resources that the CD-ROM and the screen make available to the students.

In reading the CD-ROM as a multimodal text displayed on the screen the task of the students is to understand what they should attend to as 'relevant' and 'important'. Regardless of the technology used, reading is always a matter of the reader selecting what she or he sees as being 'relevant'; nonetheless the multimodal resources of the CD-ROM and the different perspectives of the phenomena offered by the CD-ROM serve to foreground this question and task.

As I have shown in Chapter Six, the designed relationship (or configuration) of the multimodal resources of the screen, in particular the visual resources of colour, texture and shape caused some difficulties for students in their interpretation of the representation of the entity 'states of matter'. More specifically, the difficulties in interpretation that the students experienced using the CD-ROM appeared to be located around the ambiguity between everyday and scientific visual representations of the states of matter, that is, where the principles of representation stood in contrast to the students everyday readings of the visual world. For example, the visual representation of the particles in the state of matter of liquid were interpreted not as an alternative representation of a liquid, but rather as 'a part of the liquid' in which the particles are 'held like in a jelly'. The representation of the transformation from a gas to a liquid uses a bubble texture to represent boiling water and a small blue circle to represent gas particles. This visual difference led some students to separate the entity 'particles' from the state itself and led them to suggest that liquid and gas have different kinds of particles rather than to focus on the change in the arrangement and movement of the particles across states of matter.

The students reading of the visual representations in ways other than intended by the designers is not, as I have argued throughout this thesis, a matter of their 'inability' to interpret the visual, rather it is that they are using different principles than the designers to interpret the CD-ROM. In the case of the visual representation of the change in states from a liquid to a solid for instance, the students principles for interpreting the visual resources of colour, texture, shape and image are based on the

empirical reality of their everyday observations and experiences. In contrast, the designers' use of these modes appears to be based on the concept of density, compactness and inertia.

In addition to the differing principles of designers and students for reading the specific modes, analysis of the students' use of the CD-ROM suggests that designers and students bring different strategies and principles to the reading of the modal configurations of the screen. The designers of texts such as the CD-ROM *Multimedia Science School* consider the displays on the screen as multimodal ensembles. As such, they are likely to see the meaning of the visual modes of colour and image as interpreted 'through or in relation to' the written elements on the screen. Observation of the students' use of the CD-ROM *Multimedia Science School* shows that some students do not engage with all of the modal resources of the screen in order to make sense of the displays in the 'screen within a screen'. In short, some students do not read all modes as being meaningful, and in making sense of the multimodal texts of the screen they rely more on the visual modes, image and colour, than they do on the modes of writing and movement. (Chapters Four and Five suggest that the modal preferences of students also contribute to technology-mediated learning in school English and Mathematics.) I argue that the students 'trust' the empirical evidence of the visual modes more than the other modes and that they draw on these visual modes to 'untangle' the ambiguities between the everyday and the scientific representations that they are presented with on the screen.

The students reading of the resources of movement on the screen is as a general signifier of 'change'. However, in some instances the students appear to be unable to link the resources of movement with a specific meaning or sign in relation to the representation of the entity 'states of matter'. The student's ability to interpret the meaning of movement is restricted by their understanding of the theoretical entities that the signs relate to and more generally their knowledge of the multimodal genres of school science. In the move from the 'hide particles' viewing option to the 'view

particles' option the resources of movement as they are realised on the screen are underpinned by different epistemological positions to knowledge. That is, in the 'hide particles' view the resources of movement show 'change' while in the 'view particles' option the resources of movement depict the motivating force behind these changes.

As described in the previous section on the reshaping of the entities of school science different epistemological positions are embedded in the 'hide' and 'view' particles options of the CD-ROM. In selecting and switching between these two views of 'states of matter' what is 'relevant' or 'significant' to the construction of curriculum entities is changed and what the students need to be attended to is altered, alongside this the students' position in relation to knowledge is also changed. The students chose different viewing options when working with the CD-ROM in the lesson. The viewing position that they chose contributed to the shaping of the curriculum entities 'states of matter' and 'particles' and themselves as learners. Students who worked with the 'hide particles' viewing option were involved in the task of observing the everyday for evidence of the phenomenon 'states of matter' and hypothesising the reasons for the behaviour that they observed. Students who worked in the 'view particles' option were engaged in observing the multimodal representation of scientific theory of particles and recording the behaviour of particles in each state. The students who switched between the two views were involved both in the observation of 'the empirical world', prediction and scientific explanation.

The students' comments on the work sheet and around the screen show that they constructed their agency in relation to the CD-ROM 'investigation' in different ways. Some students positioned themselves as active in the investigation displayed in the 'screen within a screen' and others positioned themselves as 'passive' observers of it. The students' positioning of themselves can be seen both as a sign of their response to the ambiguity of the resources of the screen which displayed the students both as active and as observers of the demonstration, and their appropriation of the genre of

investigation in school science. Alongside the students' conception of their agency the resources of the screen enabled the students to take up different roles in the lesson, in particular the role of 'expert' or 'peer-tutor'. When working with the CD-ROM on the interactive whiteboard the teacher positioned the students as 'expert/teachers'. He achieved this positioning of the students through his talk (calling them 'Miss', asking them to explain the phenomena, posing questions), their position (at the front of the class), and their gestures with the screen itself (asking them to point out specific elements and so on).

Finally, the teacher working with the resources of the screen was involved in a range of practices with the students that drew them into a range of school scientific practices demanded by the National Curriculum. He worked with the visual resources of the screen, as described in Chapter Six, to establish the 'empirical reality' of the investigation displayed on the screen. In doing so he both reshaped and 're-produced' the traditional notion of investigation and positioned himself and the students as actively involved in its production. The teacher worked with the 'hide particles' option to establish the need for an explanation of the 'everyday' world and the need to look beyond what we can ordinarily see in order to understand the familiar. He then worked with the multimodal resources of the 'view particles' option to encourage the students to offer a scientific explanation of the phenomenon 'states of matter' drawing explicitly on the role of comparison and the resources of movement. The teacher, through his gesture with the screen and drawing attention to the multimodal resources of the screen, made a link between the role of observation, prediction and evidence in the learning of school science.

Analytical Themes as Tools for Thinking about Technology-Mediated Learning

The Multimodal Character of New Technologies

As I have shown through the analysis in this thesis, a central characteristic of new technologies is the complex interplay of still image, colour, movement and gesture, writing, sound-effect and speech. This multimodal character of new technologies mediates school learning and curriculum knowledge in English, Mathematics and Science differently than do print technologies. The ‘non-linguistic’ modes go well beyond the function that they are most often associated with of directing and maintaining student attention. These modes as they appear on the computer screen contribute to the construction of curriculum entities (ideational meaning), as well as positioning the student users in relation to knowledge (interpersonal meaning) and realising the coherence of a text (textual meaning).

Different modes offer different sets of semiotic resources and these resources shape meaning in particular ways. In each of the computer applications analysed in this thesis, for example, images offer students different resources for making meaning with than do written signs. In each case, what is displayed in image is always different than what is told in writing, even when the basis of the meaning is similar its material realisation reshapes it in particular ways. Due to the different affordances of modes each mode used in the computer applications contributes to the construction of knowledge in specific ways. From this perspective the choice of mode is a matter of ‘interested design’. This makes the question of which modes are used to represent elements on screen in a text a central question. As my analysis has shown, for example, the decision of which elements in a game or CD-ROM are given a ‘voice’ or a visual appearance, or which are given permanence on the screen, and what the user can and can not change are all important in the shaping of knowledge. The semiotic resources of modes offer students different resources for engaging with curriculum knowledge, different resources for thinking with as each mode demands different kinds of cognitive work in the task of understanding and transforming signs. For this reason, modes can not be looked at in isolation and the meaning potentials of

modes need to be considered in relation to the multimodal ensemble that they are always only ever one part of.

The multimodal character of the information environment of new technologies is not an automatic consequence of the facilities of the medium, hence the different take up and design of modes in different applications. The facilities of the medium of new technologies make it easy (easier than say the medium of the page) to draw on a range of modes, such as movement, sound-effect and speech. How these modes are taken up and configured on screen is, however, a matter of the design of knowledge: that is, what it is that is to be conveyed, to whom and by whom, for what purpose and in which context. In other words, the design of multimodal texts in the domain of new technologies is motivated and interested and as a result the multimodal potentials of computer texts are not always taken up. For instance, 'screen' can look ostensibly like a 'page', that is, it can be full of writing and little else. This can be understood as a rhetorical decision to reject the potentials of image, movement, and so on, to display 'tradition' in the space of the 'new'.

De-centring Language

As the computer applications analysed in this thesis and new technologies more generally testify, the presence of the modes of speech and writing (or linguistic modes) on the screen is often minimal. When writing is displayed on screen it is along-side other modes and these other modes, often images, tend to dominate the screen space. A range of modes are in play and, increasingly, the environment of new technology relies on 'non-linguistic' processes of communication and decision-making as people deconstruct visual symbols and click to progress. The visual links, shared visual objects and audio files made available by the facilities of new technologies can be designed to critique or mediate the written elements of a text on screen or to draw attention to potential layers of meaning and alternative readings in a written text. The multimodal facilities of the screen serve to de-centre speech and writing and to distribute the functional load of a message across a range of modes. In

the context of the screen the function of 'non-linguistic' modes is not merely to illustrate or support what is realised in speech and writing, rather these modes 'fill-up' concepts that are realised linguistically in quite different ways. Indeed as I have shown, each of the modes displayed on a screen may attend to quite different aspects of what is being communicated linguistically. Increasingly, I want to suggest that writing on screen functions as a modal sign of or a reference to, the values of specialist knowledge, authority and authenticity associated with the printed era, the 'literary text' and the educated elite.

Language is de-centred by the emphasis of the majority of computer applications on the visual potential of writing (font, resources for indicating emphasis, materiality, colour, layout, and so on) in ways that change the practice of writing and reading. (It is important to note, however, that the visual character of writing has always been present to calligraphers, typographers and others.) The visual semiotic resources of writing are used on screen (and elsewhere) to indicate and to classify the specific domains of knowledge on screen. They are used to visually distinguish between fact and fiction or the everyday and the scientific or that which is intended for a young or old audience. As words 'fly in', revolve and dissolve on the screen the boundary between writing and image appears increasingly blurred, indeed at times the boundary between word and image appears entirely permeable and unstable (Chaplin, 1994; Elkins, 1999). In this way, new technologies offer the potential to 'recast modes', to heighten the blurred boundaries between the visual and the written. At times writing on the screen becomes fully visual. When a block of type moves about the screen, interacting in rhythm with other modes, for instance, the tiny scrawl of printed words retreats to a textured pattern of lines and it is redefined as a visual representation on screen and the 'meaning' of what is written is transformed.

The de-centring of writing on the computer screen is connected, I want to argue, with the spatial resource of the screen. In computer mediated learning the spatial resource of the page is superseded by the spatial resource of the screen, and in this move the

logic of the compositional meaning space is altered. The previous seemingly unalterably fixed uni-directionality of the written text ('the page') in the 'West' is altered to multiple directionality, which disturbs the logic of the 'line' as a textual/written entity. The same visual transformation is apparent in relation to elements such as the paragraph, which might be 'transformed' into a 'box of text' on screen. The use of scroll bars on the computer screen further disrupts the notion of page (Agarwal-Hollands and Andrews, 2001). In short, the screen as a site, both historically and materially, offers different potentials for language (writing and speech) and other 'non-linguistic' modes than the page. As a consequence of this writing and speech have come to have (to be given) different 'values' and meaning making potentials on screen than they have on the printed page.

Alongside the multimodal domain of the screen, as students work with computer applications they watch the screen, gesture at elements on the screen, move the mouse, and press the keyboard, and there is little or no talk involved. This suggests that educational researchers, perhaps more than ever, need to look beyond language to understand learning. The de-centring of language in this way has important implications for literacy that are discussed later in this chapter.

The Interaction of Modes on Screen

The multiple combinations of modal resources that are possible on screen, the relations that these configure between modes through their arrangement and the semantic function of links between screens and elements are an important part of the construction of meaning. The configuration of modes on screen, the functional specialisation and functional load of modes in texts offer different meanings, and different filters for the understanding of a text. The ways in which modes are configured on screen also offer potentials for student engagement with computer texts such as the points of entry into a text, the possible paths through a text and the potential for them to re-make a text. Modes offer different ways into representation and focus on different aspects of its meaning. Alternatively the relationship

configured between modes may realise a tension between the aspects of meaning in a text – a tension that is itself meaningful. As the analysis in this thesis has shown a theme (such as ‘friendship’) may be realised simultaneously (although always differently) through a range of modes to make a theme potentially more salient than if it were realised in only one mode. The take up of modes and specific modal resources serves to shape the representation of what is included or excluded in the ‘world’ of English, Mathematics or Science, as well as the relation of the student user to that world of knowledge, and its coherence.

As I have shown, the structure of a text and the use of hyperlinks realise connections and dis-connections between screens (texts) and this contributes to the construction of meaning relations between elements. In these ways the structures and links of a text can produce a semiotic sense of containment where the path through screens is a tightly defined space, and the screen is itself boundaried. Alternatively a semiotic sense of ‘openness’ can be produced through the design of links and screen structures in which the reading path remains more open. The multimodal character of new technologies, and the multiple entry points it offers to a text, nonetheless always opens up the potential for the ‘reader’ to divert from the ‘intended’ reading path(s). In the applications described and analysed in this thesis the structures that contain and boundary a text, in a sense ‘force’ the user to make a decision, while a more open structure signals the expectation on the ‘reader’ to explore the resources and potentials for action.

Modes have been shaped through their social usage over time to realise specific functions in the context of technology-mediated learning in school English, Mathematics and Science. As a consequence of this, as I have shown, the modes carry different functional loads in the realisation of knowledge on screen. More specifically, in the applications analysed in this thesis I have shown that writing is a mode most often used for the representation of specialised subject knowledge, mathematical, scientific or literary knowledge. In contrast, movement can be

described as more often realising that which can be 'seen' in the world, our 'everyday' experiences of 'how things are', although in the case of the CD-ROM *Multimedia Science School* movement is also used to represent scientific theory (particle theory) as an 'everyday' phenomenon. In the applications discussed in this thesis, visual communication appears to fulfill a mediating function between these two domains of the everyday and of specialised school knowledge. Visual communication straddles the two domains of the everyday and scientific versions of the world, the world as students experience it and the world as it is represented in school knowledge. In this way visual representations on the screen appear to act as a scaffold which offers students a way into school knowledge.

Just as modes appear differently in the traditional school Science classroom than they do in the English classroom (Kress et. al., 2001; SEP 2002), the analysis presented in this thesis suggests that this modal difference holds true for technology-mediated learning. For instance, writing appears to have a different genre and function in the case of the English CD-ROM as compared with Maths and Science. The writing (and speech) in the English application addresses the 'audience' directly, in the form of a narrative and presents Steinbeck and the novel as central to the school subject English. In contrast, the Maths and Science application contains little writing. What writing there is on screen is in the form of lists, factual statements, classifications, definitions and instruction rather than that of a narrative form. In these cases writing functions to 'name' the visual.

The use of image in the applications also varies, in relation to context, colour, style, and use of symbolic icons. In the images of the Steinbeck CD-ROM a limited range of colours is used, the colours are muted (un-saturated) and the style of the image is that of a hand-drawn illustration (in fact a transformation of film stills in an application similar to Photo-shop). This use of colour and style serves to associate the images in the CD-ROM with the genre of literary illustration often found in a printed book. The icons used in the CD-ROM, the 'spotlight' style images of actors, the

image of a novel, playing cards, and so on serve to visually signify the subject English as a world of social knowledge, history and tradition. In the multimodal computer application, *Multimedia Science School* meaning is realised 'between' the mode of image, the limited written and numerical elements, and the movement of the elements. The use of visual resources in the application suggests the need to re-think (re-visualise) the world as it is usually experienced. The visual representation in science, of the world beyond the usual experience of people, stands in contrast to the visual association with the past in the CD-ROM designed for use in school English.

Through the use of colour, image, writing, and action in the applications designed for different school subjects different discourses are produced and realised around knowledge and the subjectivity of the learner. The illustrative examples of computer applications that are discussed in this thesis demonstrate the need for a multimodal theory that accounts for the complexity of the relations between modes.

Just as there are different conventions of how image and writing are displayed on particular pages (the pages of school books and newspapers, and so on) some patterned configurations of modal resources on screen are beginning to emerge. Although these modal conventions change over time (like all conventions) the relationship between image and writing on a newspaper page for instance is markedly different in 2003 than it was in say 1960 (Kress, 2003). At the time of writing this thesis, however, the conventions of modal arrangements on screen remain unstable and emergent conventions.

The Multimodal Engagement of Students with New Technology

This thesis demonstrates the benefits of looking beyond students' talk around the computer. In addition to the multimodal character of the majority of computer applications (including Microsoft Word that this thesis is being written on, with its animated office assistant and visual icons, etc.) students engage with these applications multimodally. They point, gesture, gaze at the screen, move the mouse

(or joystick) and click on icons and, sometimes, they talk. Just as the modal elements on screen offer different affordances for the construction of curriculum knowledge so do the different modes of interaction with the computer screen.

When a student makes a gestured 'mark' across the screen to represent their imagined movement of an element, for instance, this gesture is temporary and ephemeral. It does not demand the modal commitment (the permanence) of a drawn or animated line of trajectory with the resources of an application. Throughout the instances of technology-mediated learning analysed in this thesis students used gesture to plan and imagine, and to test theories and ideas. Through gesture the students 'created' a space of activity that overlaid the computer screen. 'Within' such applications the spatial resources of the screen itself become meaningful and these were used to indicate different kinds of activity, such as constructing elements, note taking and so on. In the case of the Steinbeck CD-ROM and *Multimedia Science School* these areas were designed and designated by the makers of the application, in the case of Toontalk these areas were created by the interaction of the students. Once the students engaged with the mouse or keyboard the character of their gestures were transformed to more 'permanent' realisations of plans and instructional gestures that, were they to be 'translated' into words, would be along the lines of 'go here' 'click here', or 'select this'.

Gaze is a resource employed by students in the organisation of their interaction with the screen often visualised in the movement of the cursor on screen. Gaze is a resource that software designers have used to engage the user since the early tool bars of the Mac Classic with 'eyes' that 'follow' the cursor on the screen, through to the humanoid robots of Toontalk. These material signs realised through gaze can, I argue, be interpreted as a multimodal sign of interest, attention and intention both of the designer and the students. I have shown that by attending to the mode of gaze what may at first be taken as lack of engagement with a text, for example, flicking quickly through the screens of a CD-ROM, can be understood as a kind of engagement.

The body posture of students is a significant aspect of their engagement with screen. As I have shown in this thesis, a student's body posture, their physical habitus, can be interpreted as a signifier of their 'genre' of engagement. To lean back in a seat and view the screen is a material realisation of a different subjectivity, a different learning experience, than an upright posture with the hand on the mouse: the former is a posture of 'leisure' and the latter one of 'study'. I am not suggesting that either is more positive in relation to learning, merely that they mark the different 'position' of the student at that particular moment of engaging with a text.

This move beyond a focus on language alone and attention to the multimodal activity of students with the screen enables different kinds of learning, engagement and students' production of 'learning spaces' to be brought into the analytical frame. This includes the 'non-linguistic' work of planning and thinking, making and constructing, playing and reviewing, and moving through and transforming texts as a part of learning. As students often say nothing as they work on the computer, especially those who have a shared history of working together (Crook, 1999), moving beyond language is important, I argue, as it re-theorises much of what goes on with and around computers as potential learning.

Multimodal Literacy

Technology-mediated learning provides teachers and students (and indeed it demands) with new forms of engagement which, in turn, require new conceptions of school literacy and literacy practices.

As the analysis of technology-mediated learning in this thesis has shown, students are engaged in the work of interpreting and making meaning with a whole range of modes, image, writing, animated movement, colour, sound-effect, music and the configuration of these modes on screen. (Indeed this is always the case in the classroom, although differently so on screen.) Students and teachers are involved in

making sense of this multimodal environment. All of these modes work together to realise meaning and writing and speech are embedded in this multimodal ensemble; each mode offers different resources for meaning making and all modes including language, speech and writing, are partial in the realisation of this meaning. For these reasons a focus on language alone can not give a full account of what literacy is (Kress, 2003). There is, therefore, a need to expand our understanding of literacy in relation to new technology and, more broadly, to re-think literacy in order to accommodate the complex multimodal literacy repertoires that young people develop in the multimodal environment that they live in (Snyder, 2002; Street, 1998).

Students learning with new technologies are involved in the complex task of interpreting the multimodal signs on screen and the relationships between them. Whereas in the recent past images have been on the whole secondary and backgrounded with respect to language in relation to formal education, this relationship is changed in technology-mediated learning (and I would argue elsewhere). This change is marked by the increase in visual representation and the visualisation of writing as a mode¹. The 'reader' is involved in the task of finding and creating reading paths through the multimodal, multidirectional texts on the screen – a fluidity that is beginning to seep out onto the page of printed books (Moss, 2001; Kress, 2003). Writing, image and other modes combine to convey multiple meanings and encourage the reader to reject a single interpretation and to hold possible multiple readings of a text (Coles and Hall, 2001). The multimodal character of the screen does not indicate a single entry point, a beginning and an end, rather it indicates that texts are layered and offers multiple entry points. This offers the 'reader' new potentials for 'reading' a text and the design of the text through engagement with it. Reading a written text on a page is essentially a linear event in which the author and

¹ Images and the visual character of writing have been foregrounded at other points in history. The reasons for the dominance of image in the past, such as the low written literacy of the population and the extreme elitism of writing, do not stand behind the current trend toward image over word. The current visualisation of communication appears to be rooted in

illustrator guide the eye in a particular direction connected to the reading of a text. Multiple reading paths have always been a part of the repertoire of an experienced reader (Coles and Hall, 2001) multimodal texts of the screen, however, redefine the work of the reader, who has to work to construct a narrative or assert their own meanings via their path through a text. The design of some children's books (such as *The Jolly Pocket Postman*, Ahlberg and Ahlberg, 1995) and many magazines aimed at young people serves to fragment the notion of narrative and to encourage the reader to see themselves as 'writers'. In doing so these texts 'undo' the literary forms of closure and narrative. Nonetheless, the potentials for movement and closure through the screen texts discussed in this thesis is fundamentally different from the majority of classic book based literary forms and offer the reader the potential to 'create' (however partially) the text being read.

I have demonstrated that the move from page to screen together with a multimodal approach to learning have important implications for traditional conceptions of school literacy as a matter of competencies in reading and writing. Against this background, however, educational policy and assessment continues to promote a linguistic view of literacy and a linear view of reading which fails to connect with the kinds of literacy required in the school with the 'out-of-school worlds' of most young people. The government's National Literacy Strategy (DFES, 1998) is, for example, informed by a linguistic and print-based conceptualisation of literacy in which the focus is on 'word', 'sentence', and 'text'. The Literacy Strategy and the National Curriculum more generally, herald new technologies as a useful learning tool but, as I hope I have shown, the multimodal character of new technologies produces a tension for traditional conceptions of literacy that maintain language at their centre. Traditional forms of assessment, for instance, place an emphasis on students' hand-writing and spelling, skills that the facilities of computers make differently relevant for learning. At the same time, assessment fails to credit the acquisition of new skills that new

globalisation and the changing relationship between work, knowledge and information (New London Group, 1996).

technologies demand of students - such as finding, selecting, processing and presenting information from the internet and other sources (Somekh et. al, 2001a). I want to suggest that the multimodal character and facilities of new technology require that traditional (print-based) concepts of literacy be reshaped as what it means to be literate in the digital era of the twenty-first century is different than what was needed previously (Gardener, 2000). If school literacy is to be relevant to the demands of the multimodal environment of the larger world, it must move away from the reduction of literacy to 'a static series of technical skills' or risk 'fostering a population of functional illiterates' (McClay, 2002). In short, school literacy needs to be expanded to reflect the semiotic systems that young people use (Unsworth, 2001).

Many others have argued that the concept of literacy needs to be expanded beyond language to account for the demands of new technology. In my opinion this has led to the fragmentation of the concept of literacy into multi-literacies, visual literacy, digital literacy, and beyond to cultural literacy, emotional literacy and intellectual literacy. I argue against this pluralising of the concept of literacy, and suggest that to talk about learning with new technology as demanding substantially different 'literacies' (Zammit and Callow, 2000), although a call for radicalism, serves to accommodate the new within the domain of the old rather than to redefine it. I think that the move to multiple literacies is an inadequate solution as it maintains and reiterates the concept of 'real' literacy as linguistic and mono-modal, and serves to isolate and fragment the complex work of what it means to be literate in a multimodal world. Students who are engaged with multimodal texts in the classrooms are not interpreting image in isolation of writing, or digital medium texts from print texts, rather they are engaged in the task of interpretation in a multimodal and multimedia environment. To separate visual literacy, moving image literacy, and so on maintains the status quo in which literacy as language remains intact and boundaried: it just has more 'competition' in the communicational world.

It is more useful, I want to suggest, to reconsider the notion of literacy itself as one of multimodal design as this reflects the ‘reality’ that modes are fully integrated, that there is not, and never has been, a purely linguistic text as writing is itself multimodal (Kenner, in press). What there has been, is an educational focus on language, a privileging of language over other modes, other modes that have always been present but not always attended to (especially within educational research). To talk of multimodal literacy is to attend to all that is going on, including the visual character of writing (font, layout, colour), to listen to the ‘breathiness’, the tone, the pitch, the voice quality of speech and to understand these as semiotic resources (meaning potentials). Conceptions of literacy need to be expanded beyond language to all modes and the static notion of literacy as the acquisition of sets of competencies needs to be replaced with a notion of literacy as a dynamic process through which students use and transform multimodal signs and design new meanings.

The Multimodal Character of Learning

In this thesis I have attempted to show how learning can be understood as a dynamic process of sign making and how the multimodal signs that students make can be seen as a realisation of their interests, embedded in the demands of the classroom and the school curriculum. I have rejected a sole focus on technology-mediated learning as verbal interaction in favour of an approach that attends to the full range of modes that contribute to this process of meaning making. From this perspective I argue that the multimodal resources of the screen can be understood as a set of potentials for meaning making and I have shown that the configuration of these multimodal resources on screen is central to what students can do (mean) with them. I have demonstrated that curriculum knowledge is shaped differently by the affordances of different modes, and that when students engage with the multimodal signs on screen in the process of learning, they learn not only from the words and speech but from a range of modes. The question of what to attend to, what to ‘make meaningful’ is a significant aspect of the work of students in relation to multimodal texts, in other words, the question of what to select as salient to the task at hand. In the relative

modal constraints of the written page the student is often under no illusion of what they are supposed to attend to, although in the case of young children learning to read and write the question of what to attend to is central to their learning. In the case of multimodal texts, however, the question for students of what to attend to is amplified.

In the classroom students working with new technologies are involved in the complex task of transforming information across and between modes, for example they may be working with a multimodal entity on screen to produce a written account of that entity - what Kress (2003) has called 'transduction'. For example, the students working with the Steinbeck CD-ROM are engaged in the task of producing a sign of character drawing on the multimodal signs offered by the CD-ROM. The work of the student is to select the criterial aspects of the entity 'character' to make their own sign, drawing on the affordances of modes, and based on their interest and the framing of the task by the teacher. Such tasks demand the remaking of signs and involve the student in the transformation of knowledge in order to remake the sign 'character' according to their interests and knowledge. The multimodal environment of the screen provides students with a range of resources for meaning making and these multimodal representations are then 'taken in' 'internalised' and become tools for thinking with. As each mode shapes knowledge differently modes attend differently to the aspects of meaning being made and modes therefore provide the students with different tools for thinking with. Given the multimodal character of the resources of new technology and students engagement with these, a language centred approach to learning and assessment therefore fails to attend to the complex activity (creativity) and learning of the students in the classroom.

The multimodal resources and facilities of new technology can reconfigure the work of the student. There are, as I have demonstrated through the analysis of instances of technology mediated learning in English, Science and Mathematics, losses and gains for learning in the change of technology and mode. However, as I hope I have shown it is not that one technology is 'better' than another but rather that technologies

enable (and demand) students to engage with knowledge in different kinds of ways, and in the process offer them different potentials for learning.

8. The Development of Multimodal Theory

In this concluding chapter I address the second aim of the thesis, the question of how the thesis contributes to the development of multimodal theory through its application in the domain of the screen and technology-mediated learning. In doing so I locate the thesis in relation to potential critical practitioner interests and to wider theoretical perspectives to technology-mediated learning.

The thesis contributes to the development of multimodal theory in five ways. First, the thesis offers a coherent theoretical framework for multimodal analysis. Second, it clarifies the conceptual terms that are central to a multimodal approach. Third, it moves away from a focus on the conventional roles of modes on screen to ask what semiotic resources modes make available and how these resources shape knowledge. Fourth, the thesis attends to both the representational modes of multimodal texts and the modes of students' practices, and the relationship between them, thereby looking at how the resources on screen bring forth and fashion the work of students – and vice versa. Linked to this focus on both text and practices is the fifth contribution of the thesis to multimodal theory in which I begin to explore how social semiotics and activity theory could be productively combined.

A Coherent Framework

The thesis is motivated by my interest in pedagogic and theoretical questions concerning multimodality and technology-mediated learning. The language of description that I develop in this thesis can be equally applied to the 'traditional technologies' of the school classroom (which rely on textbooks, models and diagrams, teacher and student gesture, movement and talk) and the use of new technologies in teaching and learning. As I have discussed and demonstrated throughout the thesis, technology always has a significant effect both on pedagogy and on the representation of curriculum knowledge. The facilities of any technology (new media in this case) and the environment of its use draw on and (re)configure representational and communicational modes in different and

distinct ways. In this sense the thesis serves two compatible aims. On the one hand it provides a 'test-case' for the development of a language of description of multimodality. On the other hand the thesis is a specific empirically based investigation of how the facilities of the screen as opposed to the facilities of the page (or of the classroom more widely) configure multimodal representational and communication forms in particular ways, to (re)shape curriculum knowledge, and possibilities for learning. By analysing instances of technology-mediated learning I show how the facilities of the medium, its particular multimodal character, interactivity, structure and hyperlinks, and the screen as a site of display, shape the multimodal representation of curriculum knowledge and the practices of teachers and students differently than other technologies.

In this thesis I offer a coherent statement of the theoretical framework for multimodal analysis of sign making and learning, with particular reference to technology-mediated learning. Other research, as noted in Chapters One to Three, has focused on the resources and affordances of specific modes specifically action, visual communication, gaze, and writing in order to identify and classify the meaning making potentials of specific modes. Where research has looked at more than one mode this research has focused primarily on the relationship between word and image, and has tended to be suggestive rather than empirically based. In contrast I have examined modes as part of a multimodal ensemble and examined specific instances of technology-mediated learning. In doing so, I have moved beyond the resources offered by separate modes to examine how modes interact and interconnect in the process of meaning making. The analysis of these modes in the domain of the screen has examined the specific ways in which a range of modes are brought into relation to one another via the facilities of the medium of new technologies.

In addition to providing a coherent theoretical framework for multimodal analysis, the thesis offers a clear framework and demonstration of how to analyse technology-mediated learning from this perspective. The method is outlined in Chapter two, and demonstrated through the analysis of the three illustrative case-study examples described in Chapters Four, Five, and Six.

Clarification of terms

Where a theory is an emergent one, as is the case with multimodality, the application of the theory can contribute to its development in useful ways. Through my use of multimodality and social semiotics in this thesis I have discussed and applied the theoretical terms to empirical data and in doing so I have articulated them in ways that are relevant to the screen and learning. In the process I have clarified some of these terms and the ways in which they relate to one another in the context of technology-mediated learning. Further I have begun to make links between the concepts within social semiotic theory, multimodality and neo-Vygotskian theories of learning, in particular the role of mode in semiotic mediation and the social forces that underpin this mediation.

As discussed in the previous chapter this thesis suggests that there is a need to re-conceptualise the term 'literacy' as a multimodal process. I show that in the domain of the screen, in which language is beginning to be de-centred and image and other modes are increasingly foregrounded, the traditional conceptions of learning and 'literacy' as entirely language based are inadequate. For the purposes of this thesis I take a pragmatic and rhetorical stance by acknowledging that in the domain of the screen mediation and communication are realised through a wide range of modes. I therefore claim 'literacy' as a term for describing the work of students with these resources. The theoretical perspective put forward here enables two things to be brought into focus simultaneously: the multimodal interaction of students and teachers with the resources of the screen, and the mediational means that computer applications make available; and it permits these to be theorised in relation to curriculum knowledge, literacy and learning. It is from this position that I argue that 'literacy' in the context of technology-mediated learning is multimodal. At the same time throughout the thesis I recognise the importance of attending to the specificity of linguistic, visual and other modes and their specific affordances in order to theorise how different modes contribute to the construction of curriculum knowledge and learning.

From Roles to Resources

In order to better understand the multimodal character of new technologies and its potential for learning, I have shown that rather than identifying the typical/conventional roles of modes (image, sound-effect, writing, colour, gesture, gaze and movement on screen) as other research has done, it is important to explore *how* these roles are realised. In the thesis I 'step-back' in order to identify the range of semiotic resources which these modes make available, and the interaction of these resources on screen, to ask how they are currently used to mean but also to ask how these could be designed to realise meaning. Shifting the analytical focus from the roles that modes tend to occupy on screen to a focus on the semiotic potential of modes is useful in two important ways. First, this shift in attention makes the *choice* of mode and modal resource central. This enables an analysis, as I have done in this thesis, which examines modal resources in relation to the curriculum and to explore how the move from one mode to another reconfigures and reshapes curriculum knowledge and experiences of learning. This explicit focus on the semiotic potentials of modes enables a more articulate process of design in which the question of what resources an application might offer students for thinking and making meaning can be clearly addressed. Second, it enables the multimodal potentials of the learning environment of new technologies to be 'untied' from convention (what has gone before) in order to explore how these can be newly configured on screen. This second point is particularly important as so much of what has gone before relate to the medium of print and the domain of the printed-page, not to the facilities of new technology and computers and the site of the screen.

The work of linguists and discourse analysts serves to identify the specific resources of language - speech and writing - in ways that have shaped the common-sense that informs how educational practitioners and the designers of teaching resources use language. In a similar way this thesis describes the resources of image, colour, sound-effect, writing, speech, and movement and the configuration of these resources on screen. In this way the analytical tools developed within the thesis provide a potential resource for educational practitioners and the designers of multimodal software applications to talk and think about the use and configuration of modes in such applications.

Much of the work of designing educational resources is 'intuitive' and many designers find it difficult to articulate their decisions of when to use image, writing, animation and so on and the principles that underlie these decisions. By focusing on the affordances and constraints of the different modes that multimodal applications make available, the thesis provides some principles for reflecting on design decisions. It addresses questions, such as 'when might image be more apt than writing?', 'what is it that movement can realise on screen that a static visual representation can not?', and so on. By exploring the configuration of modes on screen the thesis gives designers resources for thinking about what it means to represent an aspect of curriculum knowledge across a range of modes - or in only one mode - or how links and structures relate curriculum elements to one another.

By exploring the screen as compared with the page as a site of display the thesis 'tracks' the transformation of knowledge from page to screen and it reveals how much of that which is 'new' is embedded in the cultural histories of the 'old' print based media. This serves to highlight how principles of design move across technologies and media and provides a potential for reflection and re-thinking the configuration of the 'new'. The 'old' technologies are also informed by the potentials and configurations of the 'new' and the design of the screen 'spills' onto the design of the page. In other words the thesis provides principles and tools that are relevant to designers of printed educational resources, especially in an environment where there is increasing convergence between screen and page based educational resources.

The thesis has the potential to provide useful tools for teacher education and pedagogic practices, in particular in relation to the use new technologies in the classroom. The language of description provided here offers resources with which to discuss and focus attention on how the different modes can be drawn upon in the classroom. It provides principles that can be adapted to evaluate the usefulness of new technology applications. For instance, the thesis offers educational practitioners resources for thinking about how applications reshape curriculum knowledge, in particular the ways in which the resources

of the screen represent everyday and ‘scientific’ concepts differently to those of the page, and positions students in relation to the construction and production of knowledge and (re)positions student and teacher roles. The analysis of the use of new technologies in the classroom offers educational practitioners ‘tools’ for thinking about how the facilities and multimodal representations of the screen can (re)shape pedagogic practices and roles.

Incorporating Text and Practices with Texts

As commented on in the introduction to this thesis, multimodal and semiotic research tends to focus on the design and the meaning of texts. How students engage with multimodal texts, what they do with them and the practices that weave around and through these texts in the classroom is less often addressed from a multimodal perspective. Conversely, research that focuses on classroom practices, in particular research from a neo-Vygotskian perspective on technology-mediated learning, rarely addresses the multimodal resources that mediate these. In this thesis I have provided a multimodal analysis of technology-mediated learning that shifts, productively I hope, between a focus on the semiotic potential of the resources made available on screen and the practices that these resources bring forth in the classroom. I have been able to examine the connections between the design of a text and students meaning making by moving between the two analytical levels, of the resources displayed on screen and of the classroom. In short, I have been able to examine how the resources of screen have shaped learning at specific moments in the classroom. This has enabled the transformative character of learning as a dynamic, social process to be foregrounded in the thesis.

The process of analysing both the software and the student data within the thesis from a multimodal perspective makes a contribution to the development of multimodal methodology of classroom research. Neo-Vygostykian and ethnographic research on technology-mediated learning focuses on people’s practices and interaction with one another around the computer and focuses far less or not at all on the resources as they are displayed on the screen. It is analogous to research that might focus on the use of the book without focusing on the contents, formats and linguistic aspects of the book. As a

consequence it fails to attend to the effect of the resources of the screen on the character of students' engagement with the screen. By contrast the focus of social semiotic research in the domain of new technologies is on the resources of the screen (as a 'text') and rarely moves beyond the screen to analyse students' interaction with it. From both of these perspectives the simultaneous focus on the representational means of the screen and the interactions of students with each other and with the screen are not brought into the analytical frame to the extent that they are in this thesis.

In collecting the data I used two cameras to focus on the 'plane' of the screen and the 'plane' of the classroom, in particular the students' engagement with the screen. The language of description developed in the thesis applies to both 'planes' of activity, and is used to analyse two forms of (inter)action simultaneously. I treat the multimodal configuration of elements on the screen as complex sign of the application designer(s)' construction of curriculum knowledge. Alongside this, the students' multimodal interaction with the screen (their gestures, body posture, talk and so on) is treated as a multimodal sign of their engagement with the curriculum knowledge represented on screen. This offered a way to examine their transformation and production of knowledge. I transcribed and analysed the multimodal construction of signs in relation to both of these planes, focusing on how each mode and the relationships between modes realised ideational, interpersonal, and textual meaning in relation to the curriculum. This dual focus on the multimodal resources of the screen and the students' interaction is a new development within multimodal research that enables the interconnection of the resources of screen and the practices of students to be explored in detail. By focusing on both the representational resources of the screen and the practices of the students the thesis was able to broaden the analysis to look at the 'social' effects of new technologies and the multimodal character of the mediational means on learning.

Epistemological Issues and the Relationship between Representation and Realism

In this section I discuss some epistemological issues raised by the multimodal representations of the curriculum knowledge in the three examples drawn from the subject areas focused on in the thesis, English, Mathematics and Science. I take as my

starting point the notion that 'realism' is a social and semiotic construct. Different specific forms of realism are embedded in each of these school disciplines: and in the move from page to screen these forms of realism are reshaped and newly made in significant ways. I argue that educational practitioners and software designers need to be aware of the potential reconfiguration of the curriculum and of the epistemology of school subjects brought about by the move from the traditional resources of the classroom to the resources of the screen. More specifically they need to have a sense of the potential impact of this reshaping on what is presented to students as 'that which is to be learnt'.

School English recontextualises, in certain domains, the work of literary theory, which has produced various forms of the object 'the literary text' and of its elements; in the case of this thesis, the element 'character' is the focus. These appear in recontextualised form, still recognisable in the English curriculum. In the move from the literary entity 'novel' in the mode of writing and the medium of the book, to the multimodal representation of the medium of the screen there is a shift from the literary entity constructed in one theory and its notion of 'realism' to a new entity. This new entity may be most conveniently described as a 'quasi-documentary' and its different notion of 'realism' consisting of 'historical' records and information (maps, photographs, biographical information and so on). This effects, among many other changes, the notion of 'character' for instance, which shifts from its position in literary theory to one in a social theory. The concept of character that is realised in the 'novel as CD-ROM' is transformed from an entity embedded in the history of Literature and school English to one of the lived reality of people. Through the representational resources of voice, image, gesture, movement and the facilities of the screen the 'characters' are brought into existence and presented as 'real' historically existent people. In this way the literary meaning of character and its potential to impact on the moral life of the reader is reconfigured.

School Mathematics offers a theoretical repositioning of students everyday understandings of phenomena in the form of mathematical concepts represented in a scientific (technical) realism. The move from the resources of page to the resources of the

screen offer the potential for movement to be brought into mathematical representations and the engagement of students' via interaction with the elements on screen. Mathematics involves the selection and representation of elements of everyday phenomena that are significant to the interests of the subject, in the case of the example discussed in this thesis these elements are 'rule', 'movement', directionality', 'action', 'condition' and 'agency'. In the move from the facilities of the page to the screen the concept of rule is transformed from a written and numerical sequence to a multimodal and multi-directional representation. The computer application discussed in the thesis, Toontalk, draws on the realism of the sensory/everyday cartoon world of young children to represent mathematical concepts as applicable to the social world (represented via the cityscape of the programming environment). At a more complex programming level within the application a scientific (technical) realism is also present. The potential to 'move between' these two representations of the world and the domain of mathematics enables the students to make connections between their knowledge of the everyday world and the mathematical concepts that underpin the programming environment.

The move from the traditional resources of the Science classroom (e.g. textbooks, models, demonstration and investigation) to the multimodal representation of the medium of the screen offer new potentials for the representation of curriculum entities which transform the ways in which everyday (naturalistic) realism and scientific (technical) realism are realised. In the case of the curriculum entity 'particles', focused on in this thesis, for example, traditional textbooks represent the 'realism' of the everyday world and the 'realism' of scientific theory visually as two distinct, separate constructions. Similarly in classroom interaction the entity 'particles' is represented in two distinct ways, via the realism of the everyday, through examples of a solid, liquid, and a gas (sometimes shown, but often 'talked into existence') and via the scientific realism of image, gesture, and the teacher's use of models. The multimodal resources of the screen, in particular image, colour and movement, together with the facilities of the medium (more specifically interactivity and the links and structures of screen texts) afford the potential for everyday realism and scientific realism to be configured newly through their simultaneous presence on screen. In the case of the CD-ROM discussed in this thesis, the

representations of Science, embedded in scientific realism are overlaid onto the naturalistic representation of the world. The task of the students is transformed from a matter of moving from the realism of the everyday to the realism of the scientific (in which the latter ‘replaces’ the former), to the task of distinguishing between and comparing these two ‘accounts’ of the world. This representation and the choice of viewing positions (to ‘view particles’ or to ‘hide particles’) impacts on the way in which students can engage with the entity ‘particle’, and offers different potentials for learning.

The similarities and differences between the multimodal representation of curriculum knowledge and realism in the different subjects of English, Mathematics and Science is an area that I intend to explore in the future by building on this thesis and analysing more examples of technology-mediated learning. At this point it is only possible to comment on these similarities and differences in an exploratory manner.

The analysis presented in this thesis suggests that the multimodal representations of curriculum entities and the semiotic construction of realism on screen across the three subject areas of school English, Mathematics and Science have a number of similarities. Broadly speaking, these multimodal representations offer, at least potentially, different entry points into the curriculum, offer the potential to reshape entities in significant ways, reposition students to the construction of knowledge, and mediate (primarily visually) the conceptual ‘gap’ between everyday and scientific concepts and domains in new ways.

There also appear to be some interesting differences in how modes are configured on screen across the three subject areas. In particular, the ways in which modes are configured on screen, their ‘prominence’ and the relationships between modes differs between the subject areas. While language - speech and writing – is increasingly de-centred on the screen this is, unsurprisingly, more the case in school Mathematics and Science than in English. The function of writing on screen differs across the subjects. In Mathematics and Science writing is primarily used to name the canonical curriculum entities within the specialised language of the subject. In English it is used more fully to represent the concepts of the curriculum, although in the case of the Steinbeck CD-ROM

an alternative reading of these concepts is available through image, movement and the other modes made available on screen. The visual modes (image, colour, texture) are dominant across all three subject areas, including School English; however, the form of these modes and what they attend to differs with respect to aspects of the representation and construction of curriculum. For example, within English, image most often appears in the form of 'illustration' (although as I have demonstrated image is not serving the 'function' of illustration) and to locate the curriculum in the domain of people's lived experiences. This use of image provides a semiotic links between English as it appears on the screen and English as it appears on the page and serves to embed screen texts in the cultural and historical domain of English. In the case of Mathematics, it seems that visual modes provide a series of tools for the construction and deconstruction of mathematical curriculum entities. In contrast, the visual modes appear to be used in school Science computer applications as a kind of 'empirical fact' steeped in the realism of scientific theory. This serves to locate scientific texts as they appear on screen within the empirical culture and history of Science, one of objective observation and fact.

Several questions that are raised by the focus on English, Mathematics and Science in the thesis will inform the development of larger scale research in the future. These questions include 'How are modes configured differently in computer applications designed for use in different school subjects?', 'How are modes designed to attend to curriculum entities in different ways (for example how the visual representation of curriculum entities in English as opposed to Science)?', and 'How does the use of the facilities of the screen differ between school subject areas?'.

Theorising Learning

Throughout the thesis I have applied multimodal concepts in the domain of learning and school knowledge - and through this application the concepts have been clarified further. In order to analyse sign making as a social process in the school context I have shown, albeit partially, the potential for bringing together social semiotics and activity theory. In the thesis I have begun to explore some of the ways in which the concepts of multimodality and activity theory can be brought together in the analysis of technology-

mediated learning. In particular, I have shown the usefulness of activity theory in examining the social forces that underpin the activity of students and providing a theoretical account of the move from everyday to scientific concepts in school learning and the modal shaping of curriculum knowledge. Although my attempt to bring these two theories together in this thesis is at an early stage, it serves to mark my desire to contribute to both theoretical approaches in the future. This thesis is then the beginning, particularly to re-think the concepts of 'mediational means', 'semiotic mediation' and 'internalisation' as multimodal concepts, and to provide a stronger theorisation of the social forces that influence the motivated production of multimodal signs.

Social semiotics focuses on a concern and interest with semiosis that is how people make meaning; and although this theory has much to offer educational research, its theoretical focus is not that of learning and curriculum. Within social semiotics while all meaning making is clearly understood as social, and all sign makers are clearly socially positioned and shaped, the social is not theorised beyond the notion of the individual sign maker's 'interest' (Kress, 1993). The ways in which social forces, such as curriculum, school policy, the history a school subject impact on sign making is not adequately theorised within social semiotics for the purpose of the thesis. In order to locate the thesis within the social institution of the school more clearly I turned to activity theory.

Activity theory was used in the thesis as a tool to think with, a heuristic, a framework within which to attend to the social forces that underpin and produce the students' sign making and learning in the three examples of technology-mediated learning discussed in the thesis. Activity theory was used in this way to bring a range of factors into the realm of the analysis: the history of curriculum entities, the curriculum itself, the (re)mediation of the roles of student and teacher in the classroom, and so on. Within the thesis the theory of social semiotics is embedded in the framework of activity theory, with the former as the 'focus', and the latter as 'the field', enabling the students' sign making to be explored within the specific social context of the classroom.

Activity theory was used, as discussed above, to broaden the picture that social semiotic theory could provide, to bring other elements into the analysis such as the curriculum, the context of the classroom, and the roles of teacher and student. However, the research focus remained that of the multimodal resources of the screen and the shaping of curriculum knowledge through students' engagement with these resources, through a close analysis of the screen and the students' direct practices with it. These aims were the focus of my research questions and shaped my detailed analytical focus on the resources as they were displayed on the computer screen and the interaction of students and teachers with these resources. Much of the wider social activity that went on in the lessons which provided the empirical data for the thesis was therefore not at the centre of the analytical frame that I applied in the thesis.

The thesis contributes to the theorisation of the social in that it begins the task of bringing together social semiotics and activity theory in a way that enables the social forces that underlie the process of sign making and mediation to be more clearly articulated. There is no doubt that a broader social focus would have brought different and equally interesting areas of investigation into the thesis and I intend to expand the level of the theorisation of the social in my future research.

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